e magazine of aerospace technologies / MARCH 1960

3/28/60 WRF

space aeronautics

non-propulsive power: requirements vs hardware (p. 42)

PROPERTY OF
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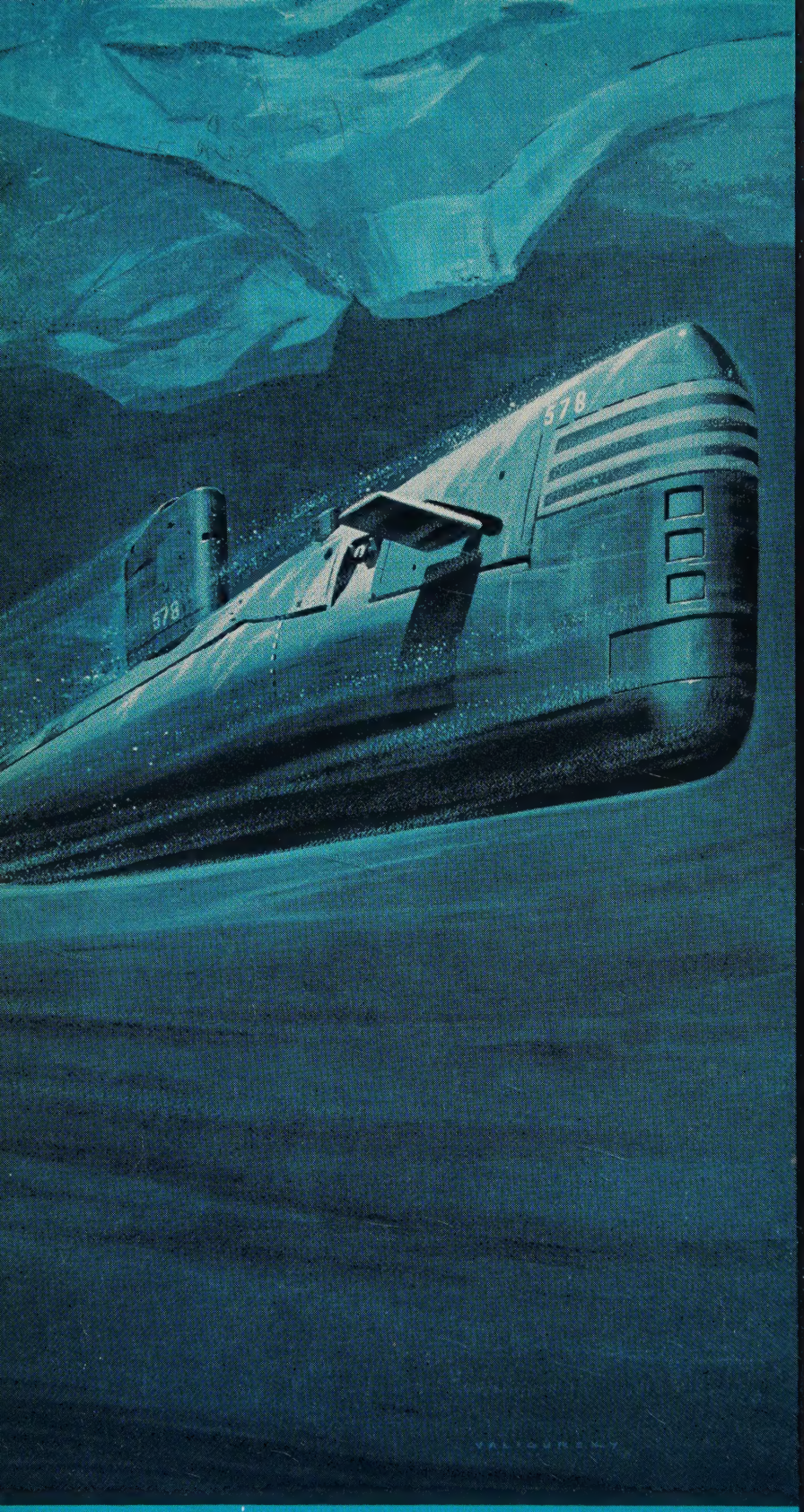
A CONOVER-MAST PUBLICATION



Crosley Amplifiers—
Under The Polar Ice Cap

Today's Navy calls for reliability. New submarines and surface ships demand technical mastery in every phase of development. When amplifiers used in underwater torpedo fire-control systems failed after a few hours of operation, the Navy turned to Avco's Crosley Division for help.

Crosley engineering solved the problem. The product: an amplifier that operates without failure for 2000 hours or longer.

Recently the Navy decided to install Crosley amplifiers in fire-control systems aboard many of its modern vessels—including the nuclear-powered submarines *S.S.(N) Nautilus, S.S.(N) Skate, S.S.(N) Sar* and *S.S.(N) Swordfish*. When the *Skate* made its historic journey under the Arctic ice cap in 1958, it had Crosley-made amplifiers aboard. Today, some ten different types of Crosley amplifiers are used by ships of the U.S. Navy.

Crosley's talent for design, engineering, and manufacture of transistorized amplifiers has secured an important place for this critical equipment. It is reflected in airborne television gun-sighting equipment purchased by the U.S. Air Force, in the huge FPS-26 height finder radar for perimeter defense, and in the Navy's *Polaris* missile system.

For more information on amplifiers designed and produced by Crosley, write . . . Vice President, Marketing-Defense Products, Crosley Division, Avco Corporation, Cincinnati 25, Ohio.

One of a series of midget servo amplifiers developed by Avco/Crosley for use in underwater fire-control systems.

UNUSUAL CAREER OPPORTUNITIES FOR QUALIFIED SCIENTISTS AND ENGINEERS . . . WRITE AVCO/CROSLEY TODAY.

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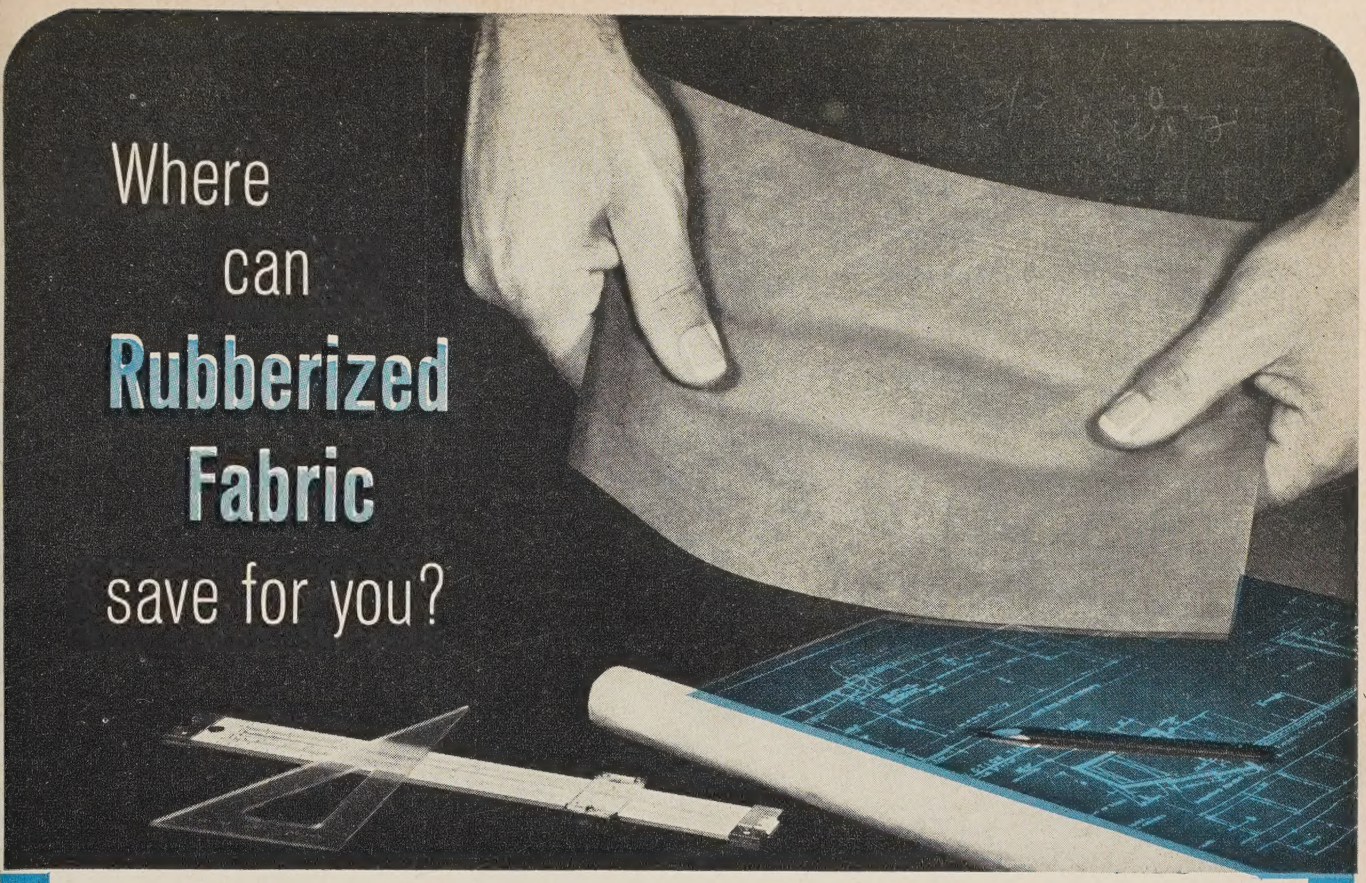
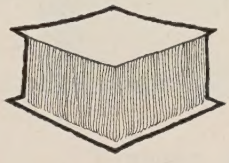


Need strength, flexibility and portability in one lightweight material? Goodyear Rubberized Fabric may be your answer.

INFLATABLE, PORTABLE

Air Mat Fabric provides excellent insulation against heat, cold, vibration. Ideal for personnel shelters, portable scaffolding, shock cushioning. Beams made of this unique rubber-coated inflatable material have highest strength-to-weight ratio known.

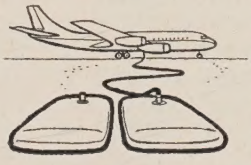


INFLATOPLANE

—another ingenious application of Air Mat Fabric. Pilot simply unfolds it, inflates it—and *flies away!* Do your plans call for a lightweight structural material that can be moved easily, occupies a bare minimum of storage space, can be erected quickly?

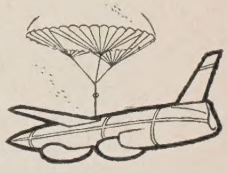
LOOK! COLLAPSIBLE FUEL TANKS

that unroll like a rug—can be set up, filled and pumping 45 minutes after delivery. Eliminates need for bulky, hard-to-handle metal drums. Designed for use wherever temporary or emergency storage of gasoline, oil, water—any bulk liquid—is required.



WANT TO BRING A MISSILE BACK?

Goodyear Recovery Bags—made of tough, rubberized fabric—fold into test missiles, inflate on way down to cushion ground impact. Saves the missile for firing another day, eliminates cost and weight of electronically operated conventional landing gear.



FOR DETAILED INFORMATION on rubberized fabric—and how it can save for you—write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

AVIATION PRODUCTS BY

GOODYEAR

Inflatoplane—T. M. Goodyear Aircraft Corporation, Akron 15, Ohio

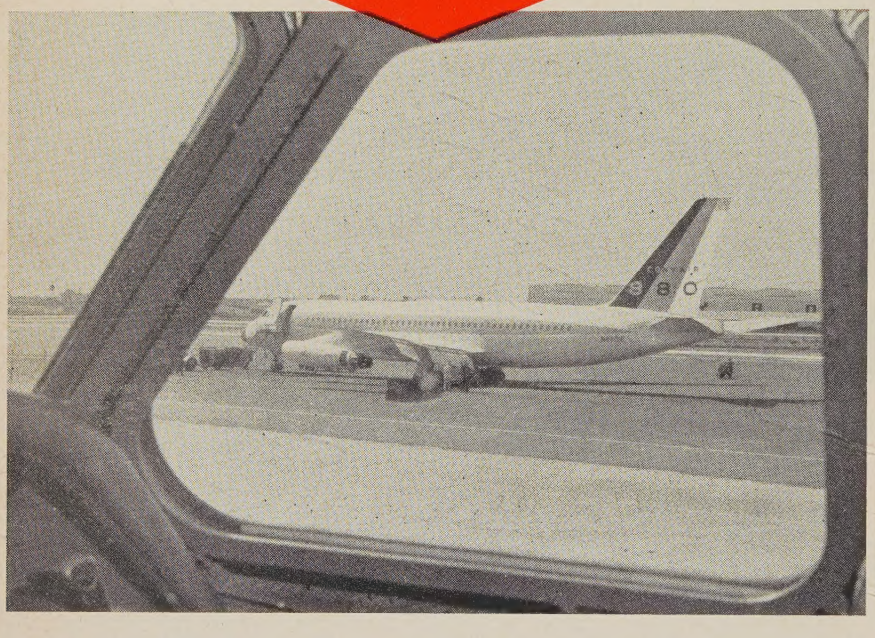
MORE AIRCRAFT LAND ON GOODYEAR TIRES, WHEELS AND BRAKES THAN ON ANY OTHER KIND

Write in No. 1 on Reader Service Card

SUPERIOR | ACCURACY

in heat controls

for jet windshields



Convair 880 jet airliners are first to use new, advanced design anti-fogging, anti-icing heat control systems developed by Magnetic Controls Company.

Windshield icing and fogging problems are considerably more complex for jet airliners, compared with those encountered by piston engine planes. With jet travel, faster speeds, higher altitudes, plus greater extremes in temperatures and atmospheric pressures, many new problems develop. Magnetic Controls proportional heat control systems have helped to solve these problems for Convair 880 jets. The Magnetic Controls systems offer four distinct advantages:

- **Automatic compensation for windshield aging.**
- **Ultra-reliable, fully static design.**
- **Elimination of thermal shock for longer windshield life.**
- **Superior accuracy – proportional plus integral control.**

For complete information about this system and how it may help you obtain precise, accurate heat control for many applications, write or phone Magnetic Controls Company today.

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Heat Control Systems • Static Inverters • Voltage Monitoring Systems

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space/aeronautics

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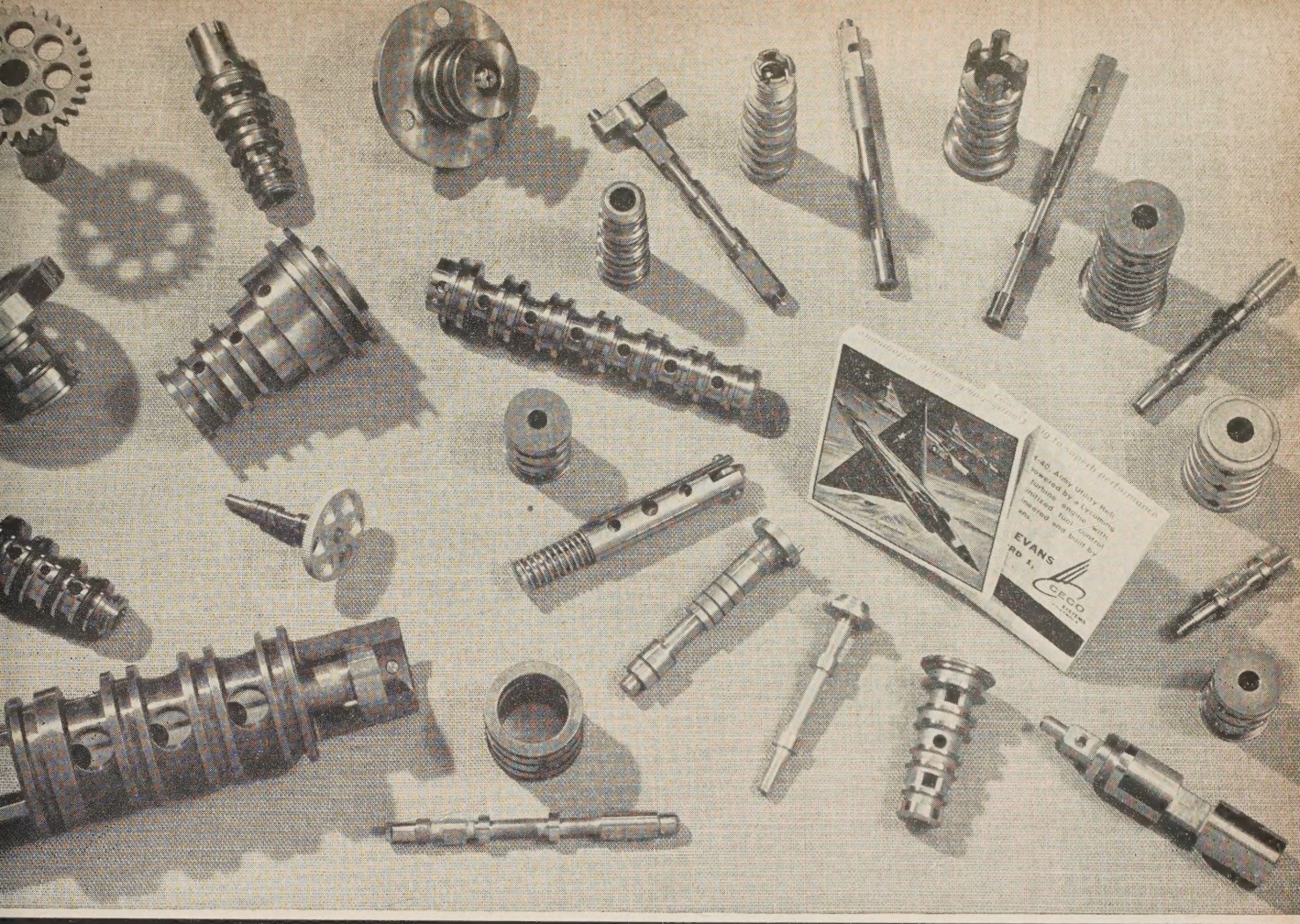
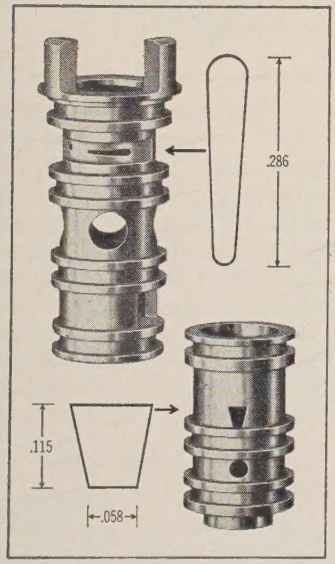


Looking for a subcontractor with real servo "savvy"?

. . . THEN TAKE A GOOD CLOSE LOOK AT THE SERVO COMPONENTS DISPLAYED HERE



As a subcontractor, CECO is equipped to handle specifications demanding production tolerances to 5 millionths of an inch and finishes to .5 RMS. Most of the servomechanism system components shown above were manufactured to just such specifications.

High-precision square holes? Other unusual porting requirements? Assignments like these are considered routine in Chandler Evans subcontract operations.

Among the "tools" of CECO's servo trade are Cavitrons, ultra-sonic cleaning devices and temperature-controlled, contamination-free assembly areas.

Components, assemblies and complete subsystems can be fabricated with equal facility.

CECO® SYSTEMS CONTROLS

For more detailed information on CECO facilities and subcontract capabilities, write Department 20 or call W. P. Carpenter, Mgr. Subcontract Sales, ADams 6-0651.

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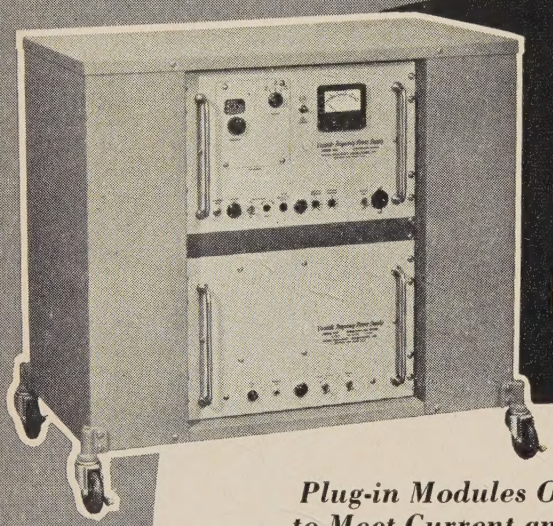
Laboratory Power Supplies



feature CHOICE OF REGULATING OSCILLATORS

Plug-in Modules Offer Flexibility to Meet Current and Future Needs

The Model 500 is a single phase, variable frequency 500 VA supply employing any of four available, plug-in oscillators (or any external oscillator) to produce selected combinations of variable power, frequency, and voltage outputs, having high stability, low harmonic distortion and excellent voltage regulation. Output frequencies are from 40 to 3000 cps, voltage from 0 to 130, harmonic distortion better than 0.5% at 200 VA to 1% or less at 450 VA, and amplitude regulation 0.5% for 5% line fluctuations. It operates from a 115 or 230-volt, 50/60 cps line and uses about 1200 watts.

Positive and negative feedback controls provide adjustment for optimum performance on leading or lagging power factors. All components are driven below rated values for extended, trouble-free service. Price about $1500.

MODEL 150

The Model 150 is a stable, single phase 150 VA supply using a choice of either an LC regulating oscillator which produces output frequencies from 380-2400 cps at 115 volts or a precision 400 cps ±.01% oscillator. In addition, an external oscillator providing 380-2400 cps frequencies at 0-130 volts may be used.

Harmonic distortion is below 1% at 50 watts and 1½% at 150 watts; amplitude variation is 0.5% for 5% line kick; stability is 0.1% ±2 cycles. Controls on front panel provide adjustment of voltage feedback for improved load matching. Operates from 115-volt, 50/60 cps line at 450 watts. Price $595.

Performance is guaranteed. Prices are net, f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U. S. A.

Write in No. 4 on Reader Service Card at start of Product Preview Section

cover story

On some advanced vehicles, especially spacecraft designs, non-propulsive, or secondary, power seriously threatens to become the limiting parameter. In a three-part series of articles, beginning in this issue on *page 42*, SPACE/AERONAUTICS analyzes this critical situation and shows the designer how to make the best use of the actual non-propulsive system hardware available today or expected for the near future. To kick off the series, cover artist George Meyerriecks has painted chemical, solar, and nuclear solar non-propulsive power the way he sees it.

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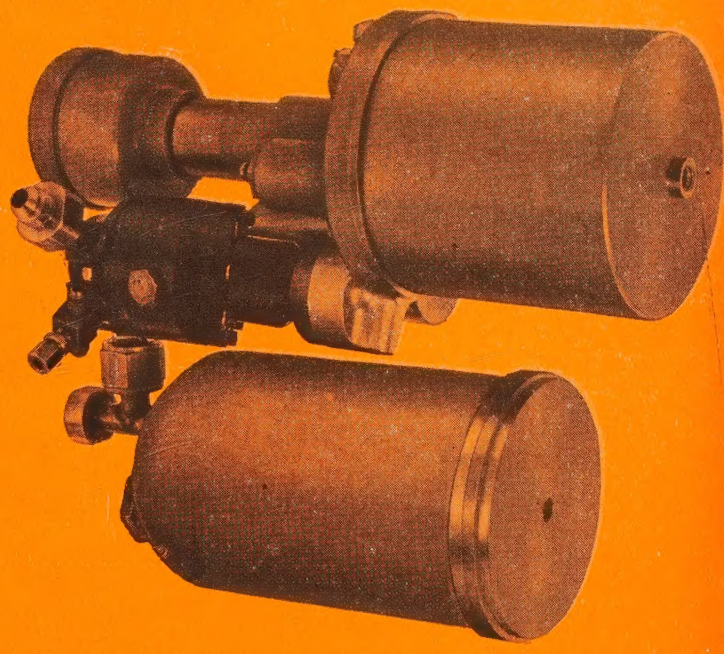
FLIGHT HARDWARE...NOW

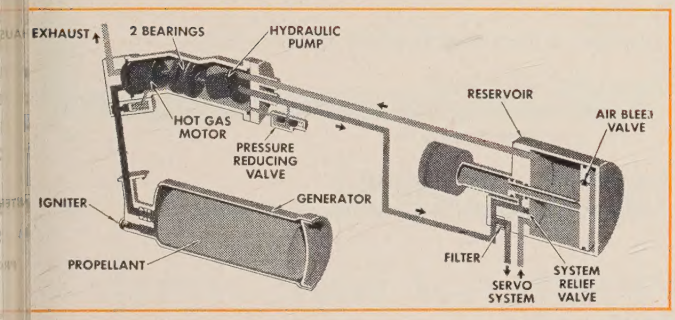
VICKERS HOT GAS AUXILIARY POWER SYSTEMS

for missiles and spacecraft



CONCEPT

Vickers piston motors — as used in virtually all existing commercial and military aircraft — are now modified to operate efficiently on propellant-generated hot gas, or bleed gas from the main propulsion system. Minimum weight is achieved by mounting the hot gas motor "shaft-to-shaft" with a Vickers piston hydraulic pump in a common housing. The motorpump, a simple gas generator, hydraulic reservoir, filter, and relief valve are integrally mounted to form a complete Auxiliary Power System in a compact package.



DEVELOPMENT

Production line Vickers hydraulic motors have been operating on hot gas for over 2 years. Units have run on gases as hot as 2300°F without modification.

The present flight hardware was built and tested after an intensive prototype development effort. Test program motorpumps have accumulated over 100 runs each for 1 minute of operation cycle. Since the current development program is aimed at meeting known APS requirements, no limits have been established on the operating cycle duration for this type of equipment.

CONCLUSIONS

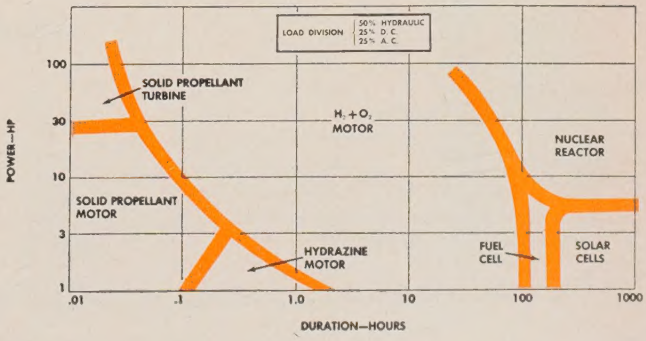
Performance and reliability goals for this concept have been met successfully. A complete hot gas APS package in the 2 - 8 horsepower range, shown above, is available within 90 days. Customer specifications for these and larger systems are invited. Write for Bulletin A-5223B.

APPLICATIONS

Because of the increasing scope of APS applications, Vickers conducted a series of studies to establish criteria for APS selection. Recent study results (published in March, 1959) indicate that for short duration operation, hot gas motors offer the best weight advantage in the 1 to 30 hp range. See curve below.

Attractive reliability and early delivery resulting from extensive use of proven hardware may extend the application of these systems to an even greater range of second and third generation missiles and spacecraft. Additional advantages include: low speed equipment (up to 10,000 rpm), convenient ground checkout, growth potential, and no alert time required.

OPTIMUM WEIGHT NON-PROPULSIVE POWER SYSTEMS



AERO HYDRAULICS DIVISION

VICKERS INCORPORATED

DETROIT 32, MICHIGAN

division of:

SPERRY RAND CORPORATION

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March 1960

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volume 33, number 3

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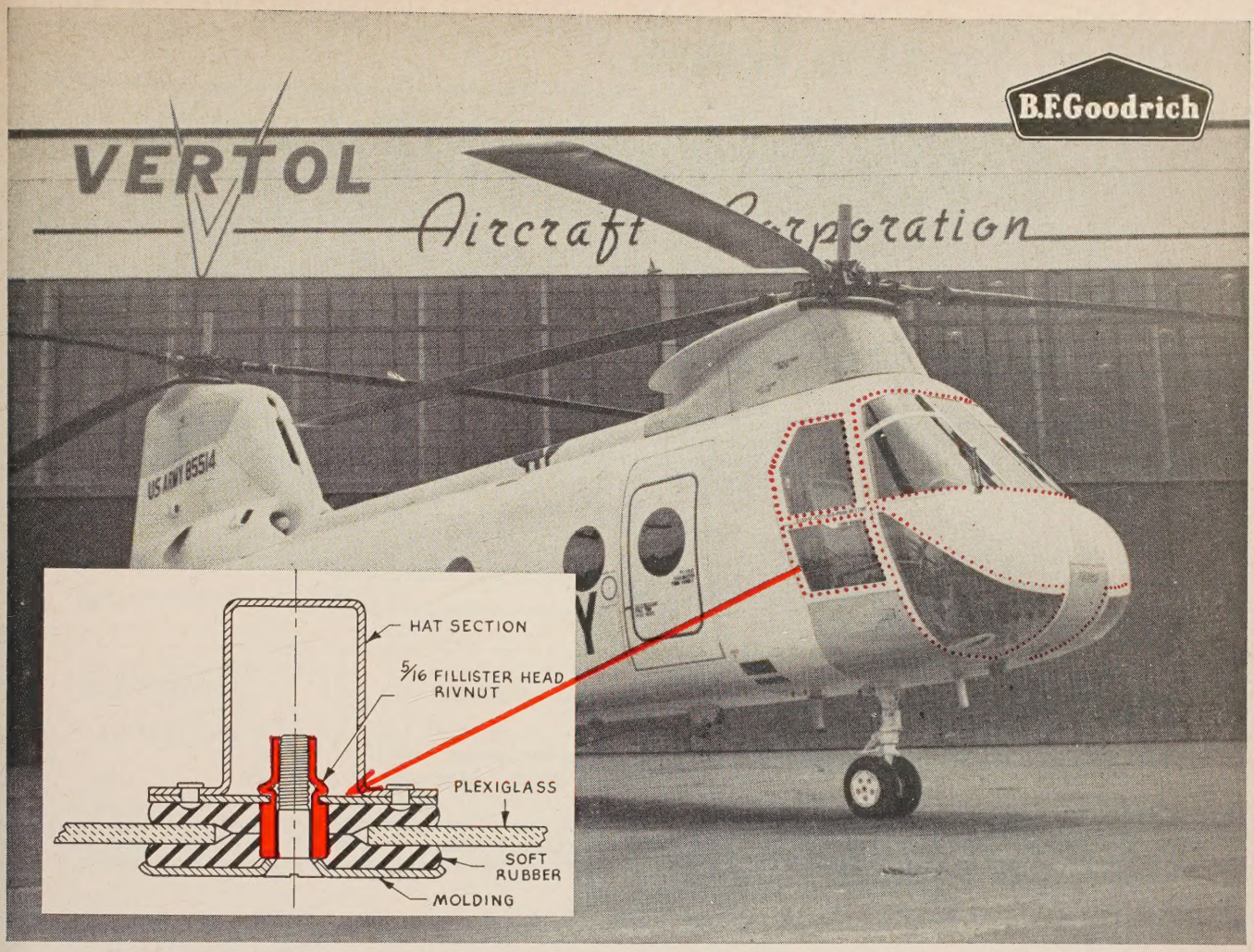


Plastic fastened to metal— firm and weather-tight with RIVNUTS®

Large transparent plastic panels form the cockpit windows of the Vertol Aircraft Company's new YHC-1A helicopter. The plastic is firmly secured to the airframe by B. F. Goodrich RIVNUTS. About 300 are installed—quickly and easily—resulting in a finished seal that withstands both vibration and weather extremes.

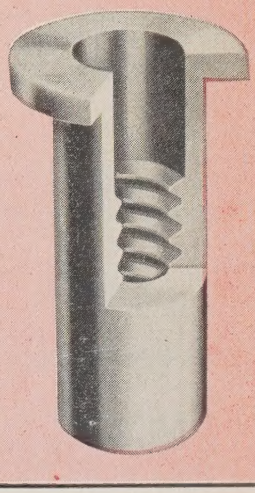
One man fits the RIVNUTS into the hat section, working from one side. These RIVNUTS act as blind nutplates. Attachment screws tighten the molding strips, rubber and plastic in a firm, weatherproof grip.

This use of blind-fastening RIVNUTS insures a simple and very satisfactory method of window installation. In case after case, RIVNUTS speed assembly, cut labor costs, simplify design. If you'd like recommendations on a specific fastening problem, please send a print of your part.

"UNILOCK" thread-locking RIVNUTS

This special RIVNUT designed for aircraft and missile fastening has V-teeth under the RIVNUT heads to lock the RIVNUT to the material. Eliminates key and keyway; reinforces the hole.

For Data Book write Dept. SA-2A, *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*



B.F.Goodrich Rivnuts

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Aerospace Engineering
Accessory Systems

Astia code: 1-2
Your code:

Non-propulsive power for advanced vehicles

Analysis of factors that determine selection of non-propulsive power systems for manned and unmanned extra-atmospheric vehicles. Shows typical load profiles for a variety of space missions; reviews pros and cons of different power systems.

by R. W. Curran, Boeing Airplane

space/aeronautics 33/3 (Mar. '60) p. 42

Aerospace Engineering
Undersea Weapon Systems

Astia code:
Your code:

Expendable sonobuoy designed for low cost production (Design Progress)

Detailed design analysis, including photos and diagrams of the complete assembly and major subassemblies. Shows details of water impact trigger mechanism, rotating head release, and automatic antenna erection scheme.

by Victor de Biasi, Associate Editor

space/aeronautics 33/3 (Mar. '60) p. 61

Aerospace Engineering
Materials

Astia code: 17-7
Your code:

State of the art: chromium and rhenium

Review of basic advantages of cooling systems using fuel fractory metals and some of their alloys. Properties discussed include tensile strength, elongation, creep, stress-rupture, and modulus of elasticity.

by Jess W. Wilson, Stanford Research Institute

space/aeronautics 33/3 (Mar. '60) p. 45

Aerospace Engineering
Dynamics

Astia code: 1-2; 12-1
Your code:

Simpler wing location for a specified longitudinal stability

Derivation of an analytical expression for locating the longitudinal position of a wing for a desired degree of longitudinal stability without the usual iterative procedure.

by Karl L. Sanders, Ryan Aeronautical

space/aeronautics 33/3 (Mar. '60) p. 67

Aerospace Engineering
Propulsion

Astia code: 27-3
Your code:

How close is a practical plasma rocket?

Review of design elements of a plasma rocket. Working fluids, power supplies, materials, ionization and accelerating devices, heat transfer, and plasma flow are discussed. Outlook for future developments and applications is assessed.

by Kurt R. Stehling, Contributing Technical Editor

space/aeronautics 33/3 (Mar. '60) p. 50

Aerospace Engineering
Accessory Components

Astia code: 1-2; 7-3
Your code:

Electric components proved out for 600 deg F ambient

Evaluation of test results for inductors, transformers, potting compounds, hookup wire, terminals, and a torque motor under severe environmental conditions. The components proved suitable for operation at 600 deg F ambient temperature in a control circuit.

by K. A. Teumer, Sundstrand Aviation

space/aeronautics 33/3 (Mar. '60) p. 75

Aerospace Engineering
Accessory Systems

Astia code: 1-2
Your code:

How to use fuel as a heat sink

Review of basic advantages of cooling systems using fuel as the final heat sink. Condensing, non-vaporizing, fuel-direct, and fuel-boiling systems of this type are described and their performance is evaluated on a comparison basis.

by G. L. Roth & O. L. Williamson, Convair-Ft. Worth

space/aeronautics 33/3 (Mar. '60) p. 56

Aerospace Engineering
Accessory Systems

Astia code: 1-4
Your code:

Minimum manual controls: stepping stone to the "electric stick"

Design details of a new, light, simple manual flight control system, developed as the first step in transition to automatic "electric stick" controls for supersonic military aircraft. System diagrams are included.

by Bjorn O. Andreasson, Convair-San Diego

space/aeronautics 33/3 (Mar. '60) p. 87

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Aerospace Engineering
Testing, Structures, Materials

Astia code: 1-3; 30-5
Your code:

Predicting the creep strength of joints

Description of methods developed by NBS to calculate the time to creep rupture and to allowable deformation for built-up structures. Testing is reduced by the application of these prediction methods.

by Randolph Hawthorne, Editor

space/aeronautics 33/3 (Mar. '60) p. 99

Aerospace Electronics

Astia code: 8-2
Your code:

Ferroelectric power source for space vehicles (Design Digest)

Analysis of operating principles and capabilities of a ferroelectric energy converter. Applications of the basic design concept to high voltage and ac generators are discussed. Curves showing efficiency of the design are included.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 33/3 (Mar. '60) p. 131

Aerospace Engineering
Accessory Systems

Astia code: 1-2
Your code:

Anti-skid braking of Russia's Tu-104 jetliner

The automatic braking system of the Tu-104 jet transport, used as medium range airliner by the Soviets, is described in detail by the designer. Configuration and operation are discussed and shown schematically.

by T. M. Bashta, Kiev Institute

space/aeronautics 33/3 (Mar. '60) p. 107

Aerospace Electronics

Astia code: 5-2
Your code:

Radio link to space can be built with today's hardware

Accepted facts on radio transmission over interplanetary ranges are reviewed. Gains of a typical system are itemized, and it is shown that a system could be built today for earth-Mars coverage. Ways of improving transmitter, antenna, and receiver performance are discussed.

by Kurt H. Meissner, Northrop

space/aeronautics 33/3 (Mar. '60) p. 141

Aerospace Electronics

Astia code: 6-6
Your code:

Finding an obstacle sensor for copter flight

Specifications of an obstacle sensor for a helicopter with a top speed of 200 kt are given. Nine types of sensors are examined; eight are dismissed because of inherent limitations. A system built around V-band radar is discussed.

by Robert Wakeman & Walton Graham, Du Mont Laboratories & TRG

space/aeronautics 33/3 (Mar. '60) p. 122

Aerospace Electronics

Astia code: 12-2
Your code:

Counterweapon systems vs the ICBM

Brief analysis by Soviet engineer of some basic problems of intercepting ICBMs. The extension of radar detection ranges and the design of anti-ICBM missiles are discussed.

by V. Kriksunov, Engineer-Major

space/aeronautics 33/3 (Mar. '60) p. 151

Aerospace Electronics

Astia code: 8-2
Your code:

How USAF expects to get reliable airborne electronics

Reliability requirements for USAF airborne-electronics contractors are summed up in digests of major parts of ARDC Regulation 80-12, Mil-R-25717C, and Mil-R-26667A. Present reliability studies are discussed, and plans for the future outlined.

by James Holahan, Electronics Editor

space/aeronautics 33/3 (Mar. '60) p. 127

Aerospace Electronics

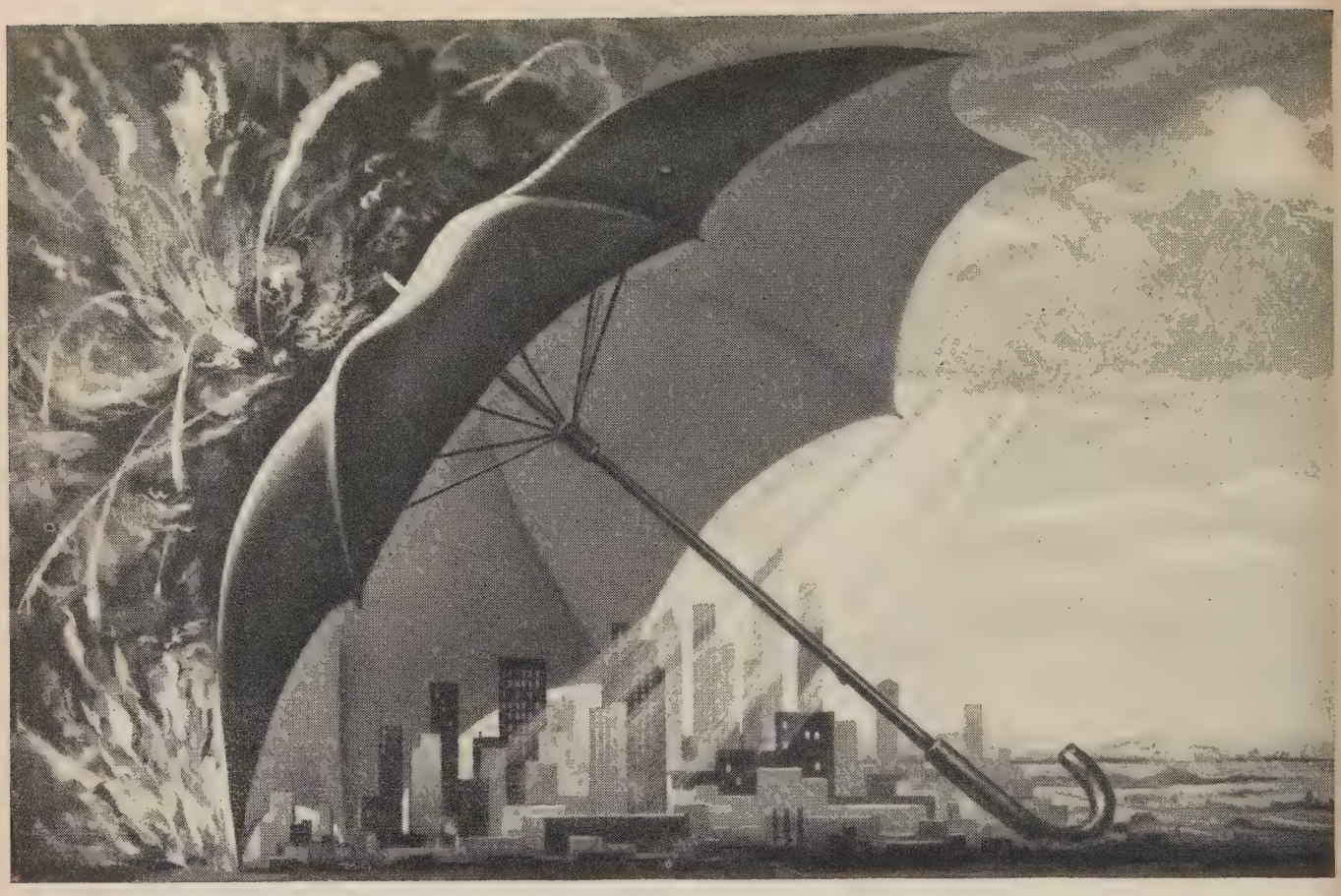
Astia code: 1-1; 12-2
Your code:

The pure-analytic approach to inertial guidance design

First of two articles detailing the design of an inertial guidance system by the pure-analytic approach. Covers the gimbal system, temperature stabilization, alignment, electric and electronic design, and miniaturization factors.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 33/3 (Mar. '60) p. 157



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coming next month

LIKE the January report on undersea weapon systems, SPACE/AERONAUTICS' next special report will cover an area that for the most part has been shrouded in secrecy in the past—electronic countermeasures. Nevertheless, our editors have broken loose enough information to fill a small magazine.

This special report will start off with two staff-written articles analyzing the technical scope and market potential of electronic countermeasures and the state of the art in this field. Next will come a series of articles by ECM experts in the ECM field on outstanding design problems. These contributions will cover system vulnerability evaluation, counter-countermeasures, airborne ECM antennas, and the outlook for future ECM systems.

In the way of direct reference material, there will be an "ECM Data File", presenting tabular and nomographic material, and a comprehensive listing of ECM contractors, giving details on capabilities and contractual experience.

CONTINUING his series on "exotic" rockets, which begins in this issue with an article on the plasma engine, Contributing Technical Editor Kurt Stehling will turn to the ion rocket and analyze the design factors that will determine the development and application of this powerplant.

THE 707s AND DC-8s aren't the only new civil transports these days, even though most of the news is about them. There is also a whole crop of smaller transports that has come off the drawing-boards with the advent of the right kind of turbine power. One of these important aircraft will be analyzed in detail by Associate Editor Irwin Stambler in next month's Design Progress.

MECHANICAL DESIGN is another area where there's little glamour. Maybe because it's so ubiquitous? In any case, we feel sure that many of our readers will welcome the series on transmission design that will start next month.

coming soon

DO YOU RUN into trouble when you try to visualize three-dimensional problems involving angles—in working on an inertial system, say, or a multi-gimbaled platform? Then watch for an upcoming series that presents in detail a proven, simplified method for visualizing and manipulating the relationships between the quantities involved in three-dimensional design.

ECM special report coming up

ANOTHER EDITORIAL "goodie" is being cooked for our readers, this time in our electronic oven. Project leader Jim Holahan, along with Associate Electronics Editor Bern Kovit, and Associate Editors Irwin Stambler and Christopher Dawson, have teamed up to do an Electronic Countermeasures report. It looks like a good one.

Having only just wiped the salt spray of the Undersea Weapons System report from their eyes, Jim and his cohorts started discussing the potential value of an ECM report with engineers and designers among prime contractors and the military services. There was a firm feeling that this project would fill a wide information gap.

The broad area of "countermeasures" that the report will include affects almost every military aerospace electronics project. Even those engineers not working directly on countermeasure equipment and systems must know the developments in this field. ECM is an environment that must be taken into account in all design and engineering specs.

Much of the technical information these people need to do their jobs hasn't been spread widely. The big block, of course, has been security. Nevertheless, not too much of the declassified material has found its way to those who need to know, Jim reports.

Here are the areas the report will cover:

- *Electronic Reconnaissance*—picking up "enemy" electromagnetic transmissions and determining the location and electric characteristics of the transmitter, determining where the "enemy's" listening stations are, getting information on the "enemy's" guidance, navigation, communications, electronic fuzing, search, and detection systems.
- *Electronic Countermeasures*—methods used to deny the enemy the effective use of his electronic equipment (jamming, decoys, radar, masking, etc.),
- *Electronic Counter-Countermeasures* — methods used to negate the effect of CM on electronic equipment.

There will be a state-of-the-art review on ECM, CCM, and electronic reconnaissance; reports on the direction of industry and military thinking; an analysis of the market picture now and for the future and of trends in ECM, CCM and ER.

In addition, there will be major articles and features covering ECM trends in space applications, nomographs, and capabilities table listing military groups and companies in ECM—what they are doing and what their major skills are in this area. ECM antenna arrays and infrared countermeasures also will be treated.

The April cover will be designed by our staff artist George Meyerriecks in keeping with the ECM motif. Look for the April special report. We think it will be another "collectors'" item for our engineer readers' working files.

Incidentally, speaking of collectors, we have been flooded with requests for reprints of the Undersea Weapon Systems report of last January. Typical of the glowing comments were:

"Your January 1960 report on UWS is a major contribution to the needed understanding of underseas warfare," said an engineer in Goodyear Aircraft's Subroc project office. Another, in GE's technical military planning operation, wrote: "I am working in this general field, and after a preliminary astonished examination of this excellent article, I wanted to assure myself of a personal reference copy."

Other activities of our editors

Last month Contributing Technical Editor Kurt Stehling acted as moderator of a panel discussion of the National Rocket Club's National Missile/Space Conference held in Washington, D. C,

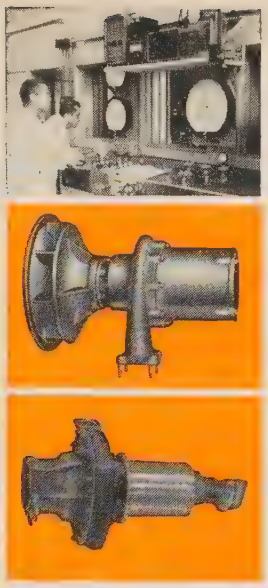
Our Undersea Weapon Systems project leader, Vic de Biasi, was invited to discuss the development of advanced UWS before the Mitchell AFB (N. Y.) Active Reserve Center.

The bearded systems editor, whose resemblance to Fidel Castro is only incidental, talked about advanced underwater jet propulsion systems; airborne, surface, and underwater ASW techniques; and the strategic and tactical use of advanced undersea vehicles, surface ships, aircraft, and land targets.

The R&D section of the Center is staffed by working scientists and engineers recruited from industry in the New York City area.

William L. Mass

Publisher



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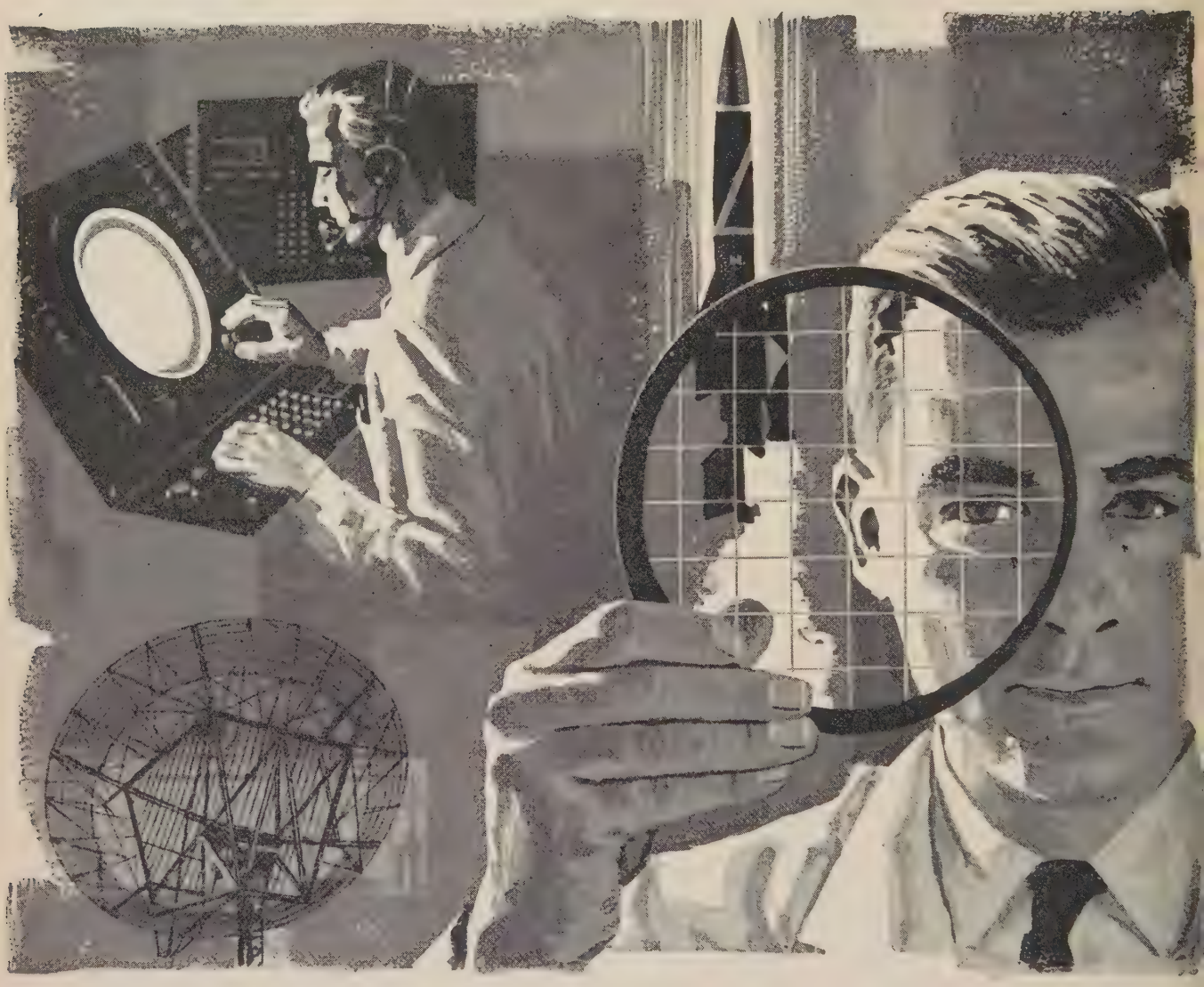

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editorial

"Adequate" defense weakens Berlin stand

ONLY LAST DECEMBER we and our allies told the world we would revert to the most unyielding position yet taken on the Berlin issue. The decision, made in Paris, implied we would reject any juridical change of the city.

But on February 4, the Red Pandemonium renewed its threat. If we do not comply with Soviet wishes, a separate East German pact will be signed.

With somewhat indecent haste, the West was reported on the same day to be willing to "ease" its views on the beleaguered city. We are now ready, the report from Bonn said, to submit to East German control over our traffic in and out of the city. Thus, Mr. Eisenhower's "inch," which he swore he would not give on the Berlin issue, already has been pulled from under his feet. Why?

The President stubbornly maintains our defense is "adequate." Adequate for what? Certainly not for backing up our foreign policy to the hilt. Certainly not for putting out all brush-fire wars. And certainly not for meeting the growing threat posed by the Soviet lead in space programs. He doesn't even recognize a threat there exists.

"I KNOW MORE about [defense] than almost anybody I think, that is in the country, because I have given my life to it, and on the basis of doing what is good for the government and for the country," Mr. Eisenhower retorted angrily to a reporter's question. But the facts seem to point to some self-delusion.

Mr. Eisenhower has implied that the Joint Chiefs of Staff, as well as the Defense Secretary, go along with his views. True, they go along with him. But the JCS individually have recommended stronger defense measures. Overruled, they *accepted* the decisions of their superior. What else can they do, but resign?

On what is our defense program based? It rests on the "best estimates" provided by the Central Intelligence Agency. These estimates are made on the basis of fragmentary known facts. There is no guarantee of accuracy. Yet our defense is geared to hewing close to the line of adequacy, the "minimum deterrent."

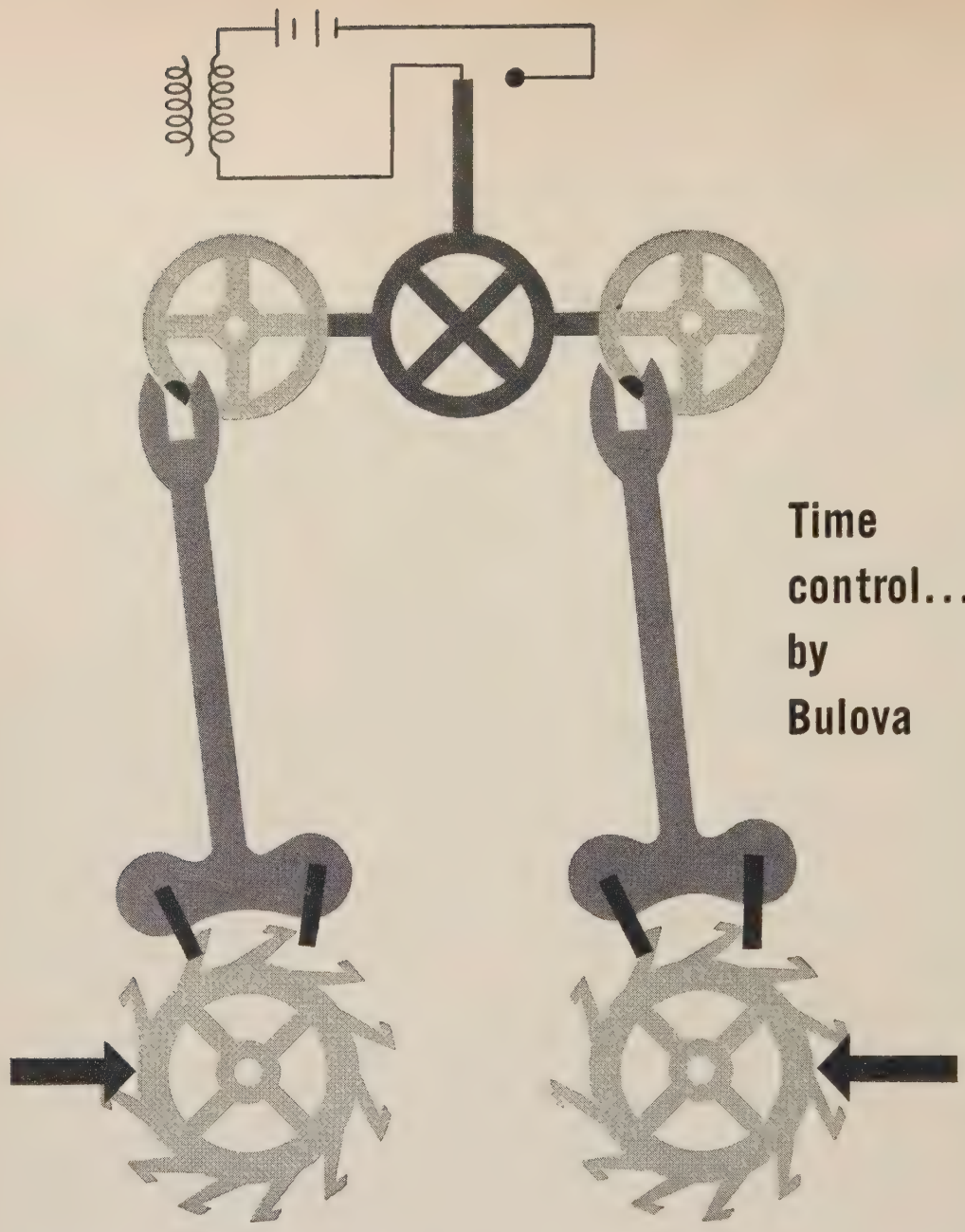
BY HIMSELF, the President flies in the face of his own Gaither Committee findings and of the Rockefeller Report on defense requirements. All the sober judgment of these civilian committees—one of which had all the facts open to the President—was brushed aside. Were these bodies also "parochial" in their views, as he has described his generals?

This one man, a self-proclaimed defense expert, stands against the tide of expert civilian and military advice, and against the rising tide of Soviet intransigence, believing only his own conclusions. Like King Canute, he bids the waves not to wet his feet. Unlike Canute, he does not see that his will is not enough to alter the facts.

General Eisenhower, the military expert, has been out of close touch with his specialty for more than a decade. Weapons, tactics, strategy, and logistics have changed radically.

How expert would the engineer be in a specialty he had left 10 years ago?

Randolph Hawthorne, Editor



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washington briefing

by A. N. Wecksler and R. M. Loebelson, Washington Bureau Chief & Associate Editor

DOD overtime ban is flexible

SINCE the middle of 1957 the military and, more recently, NASA have been under orders of "no overtime." Ballistic missiles have been excepted from this order, as well as Projects Mercury (the space capsule) and Saturn (the super-thrust rocket).

The Space Task Group set up by NASA to handle Project Mercury has been regularly authorized to work overtime. McDonnell, the prime contractor on Mercury, has been authorized by NASA to go to a 54-hour week. This action came in the form of an amendment to the cost-plus contract.

On the Saturn Project, the Army Ballistic Missile Agency, which is being integrated into NASA, has been told it may work up to 20 per cent overtime. This permission has been extended to the four contractors who are working "on post" at Redstone Arsenal (Chrysler's Missile Division, Consultant & Designers, Hayes Aircraft, and Brown Engineering). In addition, there are about a half dozen "off-post" suppliers. Overtime will be authorized for these as required.

Department of Defense has taken a liberal approach toward restrictions against overtime. Contractors who can show that it would be cheaper to work overtime than straight time on specific operations can make the decision on their own.

Beyond that, it takes the Secretary of Air Force, Navy or Army (or their designees) to authorize overtime. This sounds more difficult than it is. DOD officials claim that overtime authority can be arranged in a "matter of minutes."

The ban against overtime is contained in the Armed Services Procurement Regulations. It reads as though it were a tight injunction restricting defense production to a standard work week. DOD policy, however, is to give permission for overtime whenever this would best serve the interests of defense. The whole overtime ban is aimed at "extended overtime" payments, calling for six- and seven-day weeks. These can raise the costs of a contract "enormously."

Defense officials report that there has been a trend in the past to restrict contractors on how much overtime they could work on a specific contract. The policy has now been adopted to give the contractor freedom of decision on overtime (after general approval at the Secretarial level) but to make this practice subject to review every 3-6 months.

When contractors are allowed overtime, they can extend this provision to their subs and suppliers as needed.

• • •

Controversy begun by Defense Secretary Thomas Gates over this country's missile gap vis-a-vis Russia will continue throughout the Congressional session. But even if the Democratic-controlled Congress votes more money for defense, it will not be used by the Administration.

Gates got caught in the proverbial wringer when he talked about changing intelligence estimates. He implied that the U.S. was now basing its military planning on probable Soviet intentions rather than capabilities. But Central Intelligence Agency Director Allen W. Dulles insisted that there has been no change in intelligence appraisals. Nevertheless, Senator Stuart Symington of Missouri and other Democrats immediately asserted that the intelligence books "have been juggled so that the budget books may be balanced."

Gates concedes that the U.S. will have an ICBM gap for the next two years but insists it will be narrowed starting in 1962. He sees no need for concern, because of our continuing deter-

more on page 21

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This 120" curved section is typical missile structure.

Stainless honeycomb components for B-58 "Hustler"

Top view of new speed brake assembly.

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rent capability in the form of bombers, missiles, and Polaris-firing subs.

USAF Chief of Staff Gen. Thomas D. White also believes there is no immediate danger. "In the overall military posture, in my opinion we are not behind at all," he declared. Partially dissenting opinion by Gen. Thomas S. Power, head of the Strategic Air Command, will give Administration critics additional ammunition.

But when the comments for the record are all made, few if any additional dollars will be obligated to shorten the missile gap and speed U.S. production of ICBMs and missile-firing submarines.

• • •

With the Navy working on a program to make the Polaris solid-propellant missile into an intercontinental "bird," USAF leaders can be expected to step up demands for creation of a single strategic force. Indications by Vice Adm. John T. Hayward, Deputy Chief of Naval Operations - Development, that work is underway to give a second-generation Polaris a range of 3000 miles or more by increasing its specific impulse will intensify the not-so-covert USAF desire to control and administer Polaris firings.

Officially, USAF has no thought of placing Polaris subs under the control of SAC. AF Chief of Staff White thinks SAC and the Polaris subs should be made subordinate to an overall U.S. Strategic Command, with all U.S. strategic weapons systems under one head. In the initial stages (or until the Army has a strategic weapon), White thinks the head of the Strategic Command should be an Air Force or Navy officer who should have a joint staff. The Navy naturally is opposing the idea—it fears USAF inevitably would get control.

The USAF proposal, or some variation of it, would have specific advantages for the aerospace industry. Proposals to produce a new strategic weapon system would be made to a single group. The proposed weapon would have to compete for funding only against other strategic weapons.

• • •

NASA reports the patent policy it is forced to follow discourages industry from undertaking space work. It is asking Congress to change its law so that contractors can be assured they will get the market benefits of civilian applications of their inventions.

The space agency patent spokesmen say that their regulations are tougher than those of any other Government agency.

NASA has forwarded to Congress seven specific cases in which companies indicated they were not interested in undertaking space work unless they could be assured that they would get patent rights to any civilian applications of inventions developed by their research.

Under the NASA Act of 1958, the space agency must retain the right to take title to any invention developed in connection with a NASA contract. The agency is permitted to waive this right if the Administrator finds that it is in the best interests of the country to do so.

The complaint against these provisions is that each contract NASA makes must contain complicated clauses giving the Government the right to take title to inventions. Also there is the uncertainty on the part of the contractor that a waiver will be forthcoming.

NASA takes the position that many of its contracts parallel those of DOD. In some cases the only difference in the contracts lies in the fact that NASA rather than DOD is providing the funds for payment.

Under a DOD contract, however, the contractor merely has to report to his contracting officer any invention he develops in the course of the contract and to indicate that he will file and obtain a patent.

If the contractor files for a patent, he must give free use of the patent to the Government. If the contractor does not want to file for a patent, the Government may do so; in such a case, the contractor is granted free use of the invention.

Under NASA procedures, the contractor must report his invention and at the same time describe in detail the circumstances under which the invention was made. If these are such as to indicate that the Government has ownership, then NASA must retain the right to take title to the invention.

The NASA Administrator can waive this right if he feels that a waiver serves the best interests of the country—for example, if the acquisition of a patent by the contractor would stimulate the further development of the invention at an earlier date than if the Government held it. In the case of inventions relating wholly to outer space, it is the general feeling that these would not be developed faster if a patent were owned by a contractor.

What NASA proposes is that the Government get royalty-free rights to use inventions made under one of its contracts and that it be permitted to waive its patent ownership rights without being bound by the reservations which are now a part of its law.

There is considerable opposition in Congress to giving NASA more leeway in waiving its patent title rights. The feeling is strong among some legislators that any invention developed under Government funding should become the exclusive property of the Government.

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In the North American Aviation Super Sabre F-100, for example, designers needed a rigid material for the drag-chute case. As this chute case fits right up against the engine at the rudder base, the rigid outer wall of it must: 1) reflect heat away from the chute; 2) resist jet engine ambients; 3) retain structural strength without necessity of replacement.

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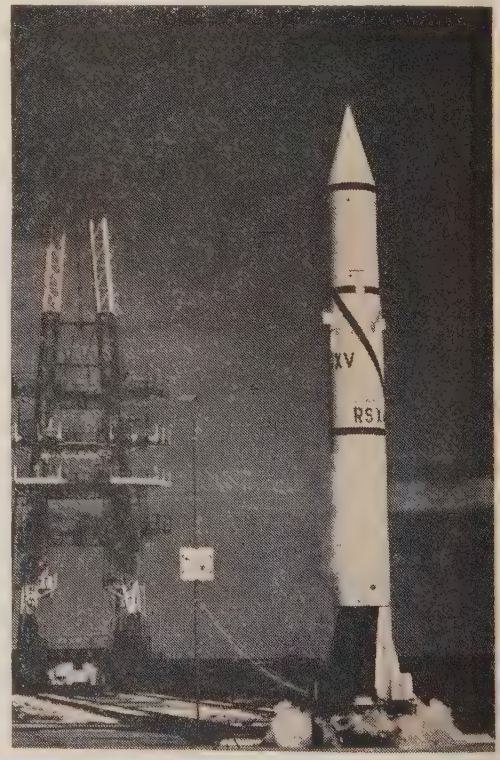
Silicones for the Army Redstone

In the Redstone, Chrysler Missile Division engineers employ silicone laminates several ways. As in the case of the F-100, large heat shields behind the Redstone's engine compartment are fabricated of the laminates because of their light weight, heat resistance, thermal impedance. Also, due to excellent electric strength and creep resistance, silicone laminates are utilized for terminal boards in black boxes within the missile and in Ground Support Equipment control boxes.



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Better management for space systems urged by Schriever

THE NATION has the technological know-how for military space systems but may be lacking appropriate management techniques. With this warning, Lt. Gen. Bernard A. Schriever is urging the same approach for our space efforts that was used on ballistic missile development. The ARDC commander specifically pointed to reconnaissance, early-warning, and communications satellites as projects which could benefit from streamlined management concepts.

Outlining these concepts, he said they call for:

- clear direct channels for making major policy decisions;
- sufficiently high priorities to obtain adequate funds;
- complete responsibility at the management level;
- highly motivated and competent personnel;
- going all-out on development of new systems once they are considered technically feasible instead of waiting for subsystems and components to be fully developed;
- the philosophy of concurrency, whereby the weapon system, production facilities, bases, support equipment, and training devices are all developed simultaneously.

•

ADMINISTRATION DECISION to add $113 million to the fiscal 1961 budget request for NASA will speed development of the Saturn and F-1 boosters by about a year. ABMA's Dr. Werner von Braun, who is working on Saturn, and Rocketdyne, which is working on both Saturn and the F-1, are both pleased with the President's action.

Revised figure makes NASA's budget request for 1961 total $915 million, as against a half-billion this year. The Saturn will now get $238 million and the F-1 about $41 million.

The added $113 million is split $98 million for Saturn and $15 million for the F-1. Both engines are in the 1,500,000-lb. thrust class. The Saturn is a cluster of eight Jupiter engines; the F-1 is a single-chamber rocket.

NASA is programing engine with 200,000 lb thrust

BIDDERS' CONFERENCE is being scheduled by NASA on proposals to produce a new 200,000-lb thrust high-energy engine. It will burn liquid hydrogen or oxygen.

NASA is programing the new powerplant for the upper stages of Saturn and other big boosters in the belief that payload capabilities can be greatly increased by upping the thrust of the first-stage booster.

Firms showing interest in the NASA-required engine include Aerojet, AiResearch, Bell, GE, Pratt & Whitney Aircraft, Reaction Motors, and Rocketdyne.

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FITTED OUT with a new charter under which it reports to Pentagon Research & Engineering Director Herbert F. York instead of the Secretary of Defense, ARPA will be able to place funded work orders with the services, make agreements with other U.S. agencies for basic and applied R&D, and obtain or build needed development and test facilities. The agency's new director, Brig. Gen. Austin W. Betts, maintains that his group will always have an important mission because it provides the management needed for high-priority or high-cost projects that affect more than one service.

All services will benefit from ARPA's work, he says, and there will be no need for triple competition. He cites ballistic missile defense and better solid propellants as examples of areas in which ARPA can be helpful.

Bargain-hunting contractors are queering USAF's pitch on surplus plants

USAF'S PLAN to sell off some plants it considers surplus is being stymied by joint industry-government ownership of many of the facilities. Air Force officials feel there is too much airframe capacity for current and projected requirements. But many contractors who might be willing to acquire the facilities they operate at a reasonable price (and thereby save the USAF maintenance costs) are thinking of getting the plants at bargain prices.

The General Services Administration will be the agency screening bids to determine whether they represent the "fair market value."

IN HOPES of encouraging bids, the AF has set up an "excess-to-ownership" category on several plants. Included are two Bell-operated plants at Tonawanda and Niagara Falls, N.Y.; AF Plant 41 for forgings at Cleveland, Ohio; Plant

more on next page

60 for extrusions at Adrian, Mich.; Plant 52, operated by Studebaker to build engines at Chicago; Plant 59, operated by GE at Johnson City, N.Y.; and the AF-owned, Douglas-operated facility at Long Beach, Calif.

DOD FIGURES showing that the top 100 contractors account for about 74 per cent of all military procurement dollars have come under fire from two members of the Special Senate Defense Procurement Subcommittee. Democrats John Sparkman of Alabama and Paul Douglas of Illinois have labeled DOD's report "unbelievable".

The two lawmakers are also concerned about the handling of R&D contracts. They are demanding that smaller companies doing research participate in this program, especially since the large producers are currently handling 97 per cent (by dollars) of all military R&D work.

Four big aerospace firms handle 40 per cent of DOD R&D

TOTAL BILLING in fiscal '59 for R&D came to $5.246 billion. This includes experimental, developmental, test, and research work. Some 500 contractors (including 397 business concerns) accounted for 99 per cent of all contracts exceeding $10,000. About 36 per cent of the companies are defined as "small business," but they accounted for only a small percentage of the dollars involved. As expected, missiles, aircraft, nuclear ships, and electronics accounted for three-fourths of the contracts.

Four of the aerospace industry's giants handle almost 40 per cent of DOD's research work; North American, with $576 million, or 11 per cent; Lockheed, with $511 million, or 9.8 per cent; GE, with $395 million, or 7.6 per cent; and Martin, with $284 million, or 5.5 per cent.

•

USAF'S PROPOSALS for a manned interceptor "more modern" than the F-104s, F-102s, and F-106s in the Air Defense Command's inventory are being given a full hearing by Defense Secretary Gates. Gen. L. S. Kuter, head of the air defense setup at Colorado Springs, Colo., has been pushing for such an aircraft ever since the Mach 3 F-108 was canceled last fall.

The proposed supersonically cruising interceptor will probably come from an aluminum version of the F-108, a new version of the B-58 bomber featuring P&WA J58 engines, and an AF modification of North American's A3J.

ARDC'S VICE COMMANDER, Maj. Gen. James Ferguson, says the '61 budget contains funds to start the development of a supersonic VTOL combat fighter "more advanced" than the Republic F-105." Ferguson revealed a tactical airplane to replace the Thunderchief "is under heated study" in the AF and adds "we believe it will be our next step in manned aircraft."

THE ARMY, which is already the largest copter-using service, is looking for ways to acquire civilian copters in case of emergency. The program is still being worked out between Army officials and the Helicopter Association of America. It is expected to have many points resembling the MATS-airlines agreement on the use of large four-engine transports, as well as the crews to fly them, within 48 hours of M-Day.

In the interim, the Army is continuing to buy large numbers of copters. The $132.5 million allotted to aircraft buying in the Army's '61 budget will include $74.4 million for 136 helicopters—primarily the Bell Iroquois and the Vertol Chinook. An additional $58.1 million will go for 83 fixed-wing planes (principally the Beech L-23 Seminole, the Grumman Mohawk, and the de Havilland Caribou).

NASA schedules projects into the seventies, expects manned moon landing as climax

WITH $915 MILLION requested for '61, NASA expects its obligations to total well over $1.5 billion after '62. Meanwhile, the space agency has outlined its program of major shots for the next decade. They include:

- '60—meteorological satellite, passive-reflector communications satellite, Scout, Thor-Delta, Atlas-Agena B (DOD), suborbital flight of Astronauts (Project Mercury);
- '61—lunar-impact vehicle, Atlas-Centaur, manned space flight;
- '62—probe to the vicinity of Venus and/or Mars;
- '63—two-stage Saturn;
- '63-'64—orbital astronomical observatory;
- '64—unmanned lunar circumnavigation and return to earth, reconnaissance of Mars and/or Venus by unmanned vehicles;
- '65-'67—first launch in a program leading to

more on page 26

THOR
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HAWK
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manned circumlunar flight and to a permanent near-earth satellite.

The possibility of manned flight to the moon is seen for the period beyond 1970.

SENATOR STUART SYMINGTON'S bill to reorganize the Defense Department (S. 2957) would abolish the secretaries of the Army, Navy, and Air Force and replace them with Under Secretaries of Defense for the three services. The Missouri Democrat's proposal would also:

- make a single overall war plan mandatory for all the services and require that the DOD budget fit that plan;
- require the creation of integrated or unified commands;
- set up a single Chief of Staff for Defense;
- give the Defense Secretary authority to transfer officers and men between the services.

LOCKHEED went into the propulsion business by acquiring a 50 per cent stock interest in Grand Central Rocket. The other half is owned by Petro-Tex Chemical, of Houston, Texas.

REPUBLIC AVIATION is negotiating to acquire Du Mont Labs. If the deal goes through, it would be consummated by an exchange of stock.

Pershing funding for '60 now totals over $118 million

MARTIN-ORLANDO got an $82.6 million contract covering additional development of the Army Pershing SSM. The Army's '60 funding on Pershing now totals over $118 million.

•

KAMAN won a $14 million follow-on award for the T58-powered HU2K all-weather copter.

AEROJET-GENERAL was picked by USAF to produce the second stage of the solid-propellant Minuteman ICBM. Thiokol is building the first stage and Aerojet and Hercules Powder are developing a third stage.

RAYTHEON received three Army contracts totaling $35.3 million for the Hawk missile, test equipment, and engineering services.

RYAN AERONAUTICAL received a $6 million subcontract from Boeing for KC-135 aft fuselages, extending production until late '61. Ryan has delivered more than 370 fuselage sections since '55.

MINUTEMAN-LAUNCHING railroad cars will be developed by an American Machine & Foundry and American Car & Foundry team under a $1 million subcontract from Boeing.

AMC ORDERED $17 million worth of GE J79 turbojets to power the Navy's F4H and A3J carrier planes.

USAF IS PLANNING to buy a total of 246 jet trainers with '61 money, including Cessna T-37s, Northrop T-38s, and North American T-39s. The number of T-39s on order rose to 42 after the AF placed an order for 25.

Air Force is backing away from weapon system management concept for good

COMPLAINTS by some industry segments about USAF's apparent disenchantment with the weapon system concept will get nowhere. Some contractors are claiming AF is backing away from the idea of placing full responsibility for a new weapon system with a single contractor and tending to buy more "off-the-shelf" items.

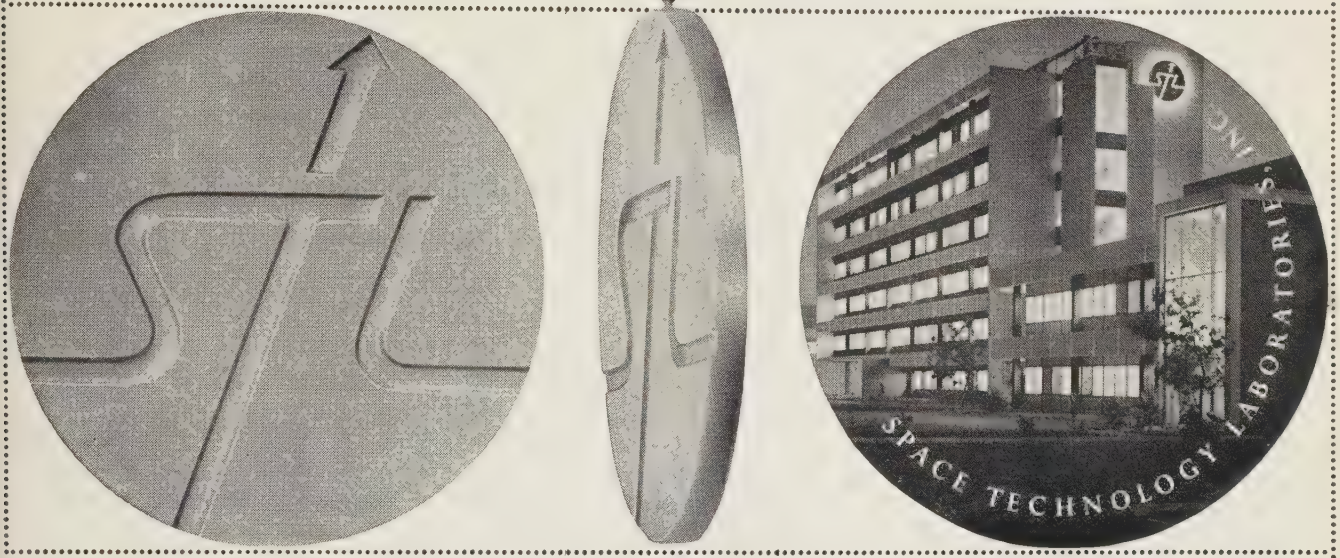
There is no doubt the Air Force is not giving primes the latitude they once had. AMC and ARDC officials candidly admit the USAF will be doing much more "looking over the contractor's shoulder" in the future. USAF demands that prospective contractors furnish "make-or-buy" reports before getting a contract are one indication of the new trend.

OTHER INSTANCES involve USAF's decision to retain the prime contractor role for itself on some new weapon systems and farm out segments to individual companies. The Minuteman program is a good case in point.

While the trend is away from the use of outside management contractors, USAF will continue to employ companies like Space Technology Labs and Mitre where they prove helpful.

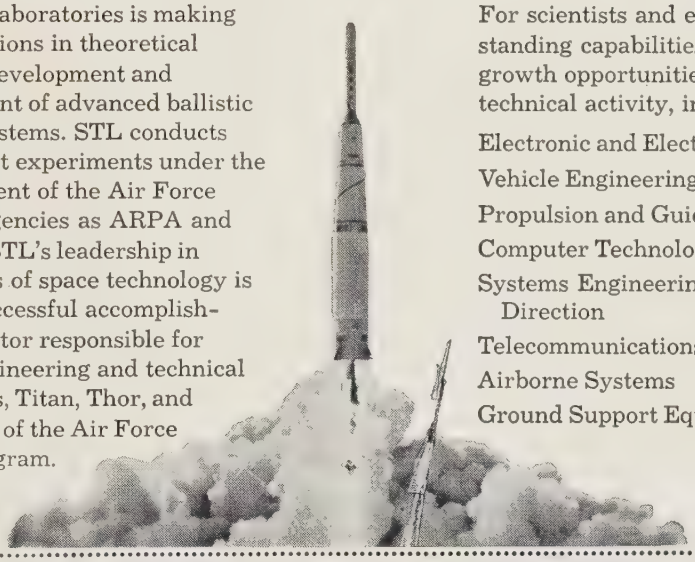
One big reason for the change is AF's belief that it now has enough technically competent men in uniform and in civil service to administer complex weapon systems. Another is USAF's contention that costs can be kept down if the service is a full participant in development rather than a virtual onlooker. A third involves the growing belief by some AF officers that the original weapon system concept proved too costly.

SCIENTISTS AND ENGINEERS: There are two sides to the STL coin...



What STL does:

Space Technology Laboratories is making significant contributions in theoretical analysis, research, development and technical management of advanced ballistic missile and space systems. STL conducts advanced space flight experiments under the executive management of the Air Force on behalf of such agencies as ARPA and NASA. In addition STL's leadership in military applications of space technology is illustrated by its successful accomplishments as the contractor responsible for over-all systems engineering and technical direction of the Atlas, Titan, Thor, and Minuteman portions of the Air Force Ballistic Missile Program.



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NEW YORK INTERVIEWS FOR MEMBERS OF IRE

For the convenience of those attending the Institute of Radio Engineers meeting, members of STL's Technical Staff will conduct personal interviews in New York, March 21-24. For an appointment, please telephone Mr. Robert Galbraith at STL's IRE suite, or send a complete resume to *Space Technology Laboratories, Inc., P.O. Box 95004, Los Angeles 45, California*

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industry viewpoint

by **Robert M. Loebelson,** Associate Editor

Training in the push-button era

AT A TIME when there's so much talk about push-button operations, it's natural to forget that it is a man who pushes the button. Alexander Long, president of small but growing Servonics, Inc., of Alexandria, Va., is convinced that more attention should be paid to training the man, even for push-button activities.

Says Long, "The best way to accomplish this is to make certain that the man involved gets realistic training, not just a canned one-shot problem." He maintains that realistic simulation devices can go a long way toward solving the problem of keeping men fully trained for civil or military aerospace operations.

Long declares that the Federal Aviation Agency has taken a tremendous forward step in its attitude toward simulation equipment. (It even went so far as to install training simulators at job sites)' "The military services are coming around too," Long adds. "They are starting to realize that the more complicated a weapon system is, the more helpful realistic simulation equipment can be."

The Servonics executive doesn't say that the military services and FAA are not spending enough on simulators. "Obviously," he says, 'no outsider can properly judge how much they should allocate to simulators." But, he adds, "there are still many undeveloped areas where simulation could be helpful."

Long insists that the new high speed aircraft and missile systems are so complex that it is sometimes physically impossible to give a crew full training with the actual vehicle. "Take some of our air-defense missiles. In some instances, we can't afford to fire the actual weapons because of the cost. In other cases, air traffic control regulations keep a so-called attacking plane from coming in for a pseudo-attack. The only other way to keep air-defense crews ready for an enemy attack is by some sort of training devices that can effectively duplicate an actual assault. One big hazard in this regard is that trainees are sometimes not impressed by a great big blob showing up on some simulated radar screens, and the training is almost useless."

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ALEXANDER LONG, president, Servonics, Inc.

Servonics' president, who believes that sonar simulators can be just as effective as radar-duplicating devices, contends that in one respect, the military services in the past have been unrealistic about simulating equipment.

"They have always insisted that simulators must be more reliable, more accurate, and less costly than the actual combat equipment they copy. This attitude is an impossible one. Obviously, training equipment that will do the same job as actual combat equipment must be just as costly. On the other hand, this type of equipment is invaluable for training a complete crew."

As military and civil flight operations become more complex and a higher level of performance is required of the men in the control towers and combat intelligence centers, the military and FAA will have to spend much more than they do now to attain better performance, Long says.

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Orbital course changes through re-start of engine

RE-START AGENA satellite stage for Discoverer series was shown in first public hot firing at Lockheed Missile & Space Division's test complex in the Santa Cruz, Calif., mountains. The engine is an advanced version of the single-firing, liquid propellant rocket used for the six polar-orbiting Discoverer satellites launched so far.

Re-start capacity permits starting engine after the satellite is in orbit for changes of the orbital path. Aim of the program, Lockheed officials stated, is to increase either payload or altitude capability.

To get the re-start capability, tank capacity and weight had to be about doubled from the earlier design. The new engine, developed by Bell Aircraft under subcontract to Lockheed, provides about 15,000 lb thrust.

ENGINEERS REPORTED the re-start Agena has been successfully re-started many times under near-vacuum conditions, and there's a "high degree of confidence that it will perform properly in actual launches." The Agena satellite, it was stated, is likely to be launched with an Atlas booster sometime this year.

In a typical re-start mission, the Atlas booster drops off after burnout, with the satellite vehicle near the orbit altitude. Agena coasts on upward, continually stabilizing itself to a horizontal position with reference to the earth's surface. The engine then fires to bring the craft to orbital speed at injection into the orbit at perigee. At apogee, a timer re-starts the engine to provide the extra boost for changing the original elliptical orbit to a high altitude, near-circular orbit.

Test stand designs for simulated launch and flight shown

SOFT-STAND design for Agena and Polaris tests was shown at the Lockheed Santa Cruz site. The stand is equipped with four large steel struts, or mounts, that lock onto a steel collar around the middle of the test vehicle. Struts are anchored at lower ends to hydraulically operated assemblies. A secondary system of four lightweight restraints makes up an inner harness used as a safety system in case the primary restraint system fails and for adaptation to unique missile structure features.

The system permits longitudinal and lateral movement as well as angular motion in pitch and yaw during simulated launch and flight. At present, the Lockheed complex includes one and two Polaris Agena stands. Height of the Agena stands is 50 ft, 5 in.; maximum capability allows for 300,000-lb thrust engines.

■

NEW USAF SATELLITE test center at Sunnyvale, Calif., was dedicated by Lt. Gen. Bernard A. Schriever, ARDC commander. Believed to be the first of its kind in the world, it will take over control of the Discoverer series—whose aim, Schriever stated, is to produce a working military satellite system. The Discoverer program, he said, will save months of trial and error on future operational programs like Midas, Samos, etc.

The center will be operated jointly by the recently activated 6594th Test Wing (Satellite) and Lockheed. It has voice line contact with the launch squadron at Vandenberg AFB, Calif., tracking stations at Kodiak, Alaska, Kaena Point, Hawaii, New Boston, N.H., etc., as well as tie-ins to computer complexes, and other communications links.

Schriever points to great potential of Midas and Samos satellites

MIDAS, Schriever noted, will use infrared sensing devices to detect the launching of enemy missiles, while Samos will act as surveillance satellite. "Assurance of warning and the understanding by the enemy that we have this contributes to our deterrent position," he said.

These vehicles, Schriever also pointed out, have a very great potential for correcting the imbalance in military intelligence caused by Soviet secrecy. "We must pursue the development of space systems with the same intensity with which we have supported the ICBM program," he said. He also noted that Agena would be used with an Atlas booster for both Samos and Midas.

THERE HAVE BEEN no budget cuts on either Samos or Midas, Schriever said. These programs are under constant review, he said, and may be increased in the future. Midas is not being pursued concurrently with Samos, Schriever said.

THIRD LINK IN USAF'S Satellite system is a communications type. Studies on it are underway, Schriever said. There is no hardware program so far, but the ARDC commander believes one will probably be set up this year. The Army, said Schriever, has responsibility for payload in this

more on next page

program, with the Air Force responsible for booster and system integration.

SCHRIEVER SAID USAF has a number of studies underway on defense against ballistic missiles, but no program for hardware. Studies are also being run on anti-satellite defense systems, anti-ballistic missile satellite systems, etc.

The Douglas ALBM program, Schriever noted, is under very detailed technical study. This is a very complex system, said Schriever, and before any hardware is decided on, it's necessary to be sure the optimum or a near-optimum design has been found. However, he said the program will probably be ready to move forward in the near future, possibly in an accelerated effort.

ELECTROMAGNEIC induction damping was suggested as a way to reduce vibrations in vehicle skins caused by high sound levels. Said L. B. Cherry, of Lamar State College of Technology, Beaumont, Tex., at a recent AIEE meeting, "The damping force is achieved by allowing an aluminum ring to vibrate in a strong magnetic field. The ring is fixed to the inner surface of the skin section and the permanent magnet which provides the field is rigidly mounted on the supporting structure.

"Relative motion between the ring and the magnetic field results in an induced voltage in the ring. Although the voltage is low, the very small electrical resistance of the ring results in the flow of large current. The resulting current reacts with the magnetic field to produce the restraining force of the ring. Experimental results indicate that, with this type of damping, the vibration amplitude of a typical skin panel under constant vibratory excitation will be only three per cent of the amplitude it would have without damping."

Aircraft-like manned boosters plugged for launching space payloads

MANNED BOOSTERS may be cheapest for launching heavy payloads into space, P. R. Shipps, of Convair-San Diego told a recent IAS meeting. Such a vehicle, he said, would resemble an aircraft rather than today's rocket designs and attain speeds of over 6000 mph. One such booster, he said, could be re-used for up to 200 launchings, according to Convair studies involving satellite payloads weighing 10-20 tons.

SELF-BROACHING fasteners are used to provide leak-proof riveted joints in the LOX compartment of the Thor missile, Douglas states. The fastener, which is patented by Douglas, was developed jointly by Douglas and Huck Mfg. Huck vice-president H. G. Brilmyer states that "Douglas engineers came up with the idea of appling integral broaching teeth to a close-tolerance Huckbolt fastener; the fastener is thus able to automatically finish-broach its own pre-drilled hole during installation."

The fastener is applied without either lubricant or sealant on either the fastener pin or the LOX compartment surfaces. The fastener collar occasionally requires some lubrication.

Solids with 2,000,000 lb thrust forseen by Rocketdyne

NEW BUTADIENE-BASED propellants make solid rockets with 2,000,000 lb thrust feasible, J. E. Medford, A. B. Boyd, and W. M. Burkes of Rocketdyne's Solid Propulsion Operations, McGregor, Tex., told a Princeton symposium. Three possible approaches for making such a motor (using 720,000 lb of propellant with typical mechanical properties) were discussed: single grain, compartmented grain, and modular grain.

All three methods are feasible, the engineers stated, but the case-supported monolithic, or single-grain, design is simplest to make and so preferable. However, it requires propellants with good physical properties. The compartmented- and modular-grain designs offer solutions for problems of stress concentrations and slump for propellants of lesser physical properties, the engineers reported. Size of a 2,000,000 lb solid propellant engine, it was stated, would be 15 ft diameter, 66 ft overall length, and 53 ft grain length.

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DISINTEGRATION BARRIER may limit man's exploration of space to "only the closest stars," Dr. E. T. Benedikt of Northrop's Norair Div. told a recent meeting of the American Astronautical Society. "To reach any of our galactic neighbors [more than] 100 light years (600 trillion miles) away in a human's adult lifetime, a space vehicle would have to travel at a speed almost equal to the speed of light." If such speeds could be attained, collision with microscopic interstellar dust particles would cause disintegration of the vehicle, he said, at about 185,000 mps.

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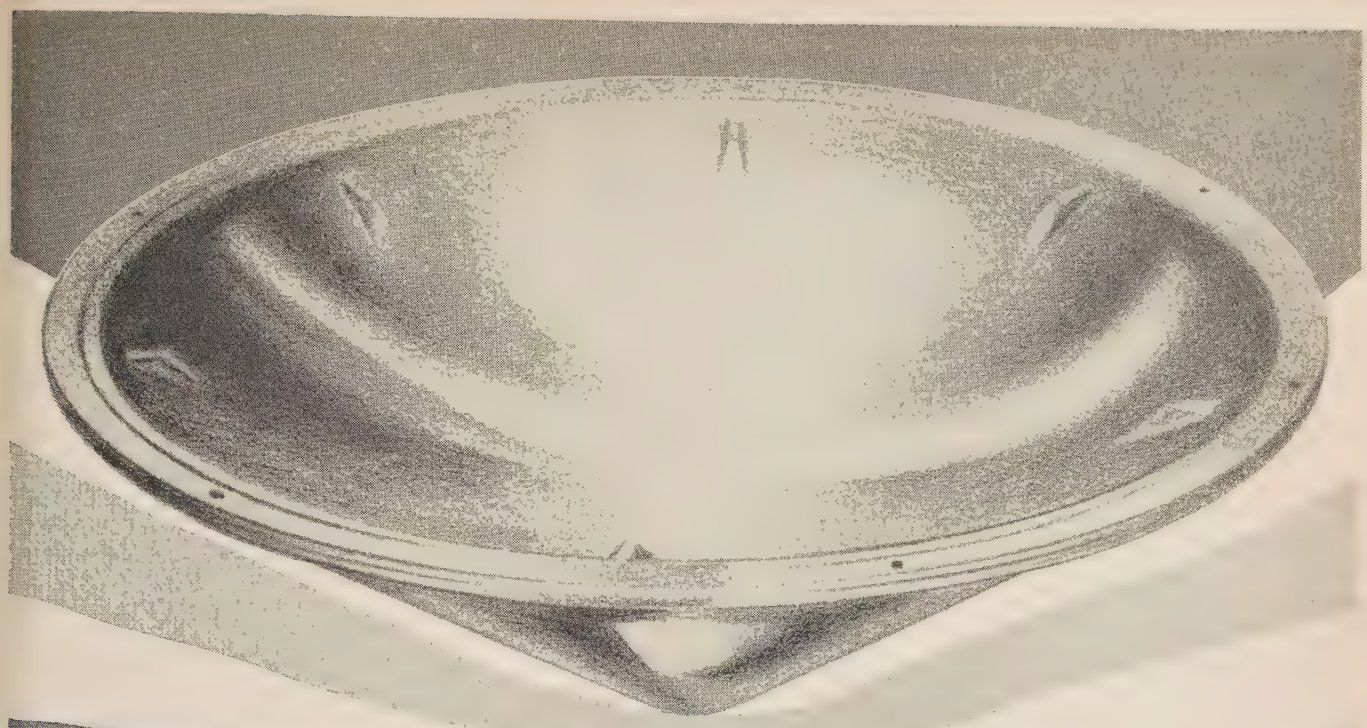

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ARMY HAWK missile's rocket motor was subjected to water immersion and cold freeze in a recent series of qualification tests. It was immersed in four feet of water at 70 deg F for eight hours and then withdrawn. The weather seal was then broken, and the Aerojet engine was put back in the water, drained without drying, and conditioned at zero deg F for 48 hours. It was then fired successfully.

First aerodynamic Zeus test a success, says Army

TEST FIRINGS of the Army Nike-Zeus anti-ICBM missile are being made to evaluate its aerodynamic characteristics. The first test in this series, in which guidance fins were locked in the zero-degree position so that the missile flew an unguided ballistic course, was a success in all respects, says the Army.

•

HOT-GAS-SYSTEM development contract for space control applications was awarded to Bendix by the Air Force. Bendix will develop, build, and test a hot-gas flight stabilization and control system for semi-orbital vehicles. The major operational advantage of such systems, according to Milo F. McCammon, general manager of Bendix Eclipse-Pioneer, is that they operate on mechanical principles. They have no electronic components and are unaffected by radiation or high temperature.

First phase of the two-year contract is already underway. It calls for Bendix to make an industry-wide survey of all existing subsystems and components that have hot-gas control possibilities.

NEAR-2000-DEG F WINDOW for space capsules was developed by Corning Glass Works. It can take temperatures approaching 2000 deg F for a short time. Made up of four panes of glass in the form of a trapezoid, the window is 21 in. high and 7½ in. wide on the outside at one end and 11 in. wide at the other.

PRACTICAL ION ENGINE depends on the development of a compact power supply or generator. Best bet is a nuclear reactor for direct conversion of heat to electricity.

FOURTH POWERED flight of X-15 lasted only a few minutes. The plane was launched at 50,000 ft, climbed under power to 60,000 ft, and then glided to a landing.

HYDROFOIL CRAFT CONTRACT was awarded to Dynamic Developments, a Grumman affiliate, for the design and prototype of an 80-ton, 60-80 knot "open sea" all-aluminum vehicle. The contract came as the result of Grumman hydrofoil feasibility and design studies over the past two years.

The 104-ft-long craft will be powered by an aircraft-type gas turbine engine. It will be 21½ ft wide and, with hydrofoils retracted, will draw about six feet of water. So far as the aerospace industry is concerned, the most important military applications of hydrofoil craft will be high speed antisubmarine detection and anti-sub missile launchings.

MAIN FOILS, or wings of the hydrofoil craft, are just forward of the CG. A smaller lifting surface is located well aft of the CG. Automatic "flight control" systems provide stability and damping in rough water.

MIDGET TURBOJET weighing 23 lb and producing 70 lb of thrust has been developed by Williams Research, Walled Lake, Mich. Company president Sam Williams says the design approaches the thrust-per-pound ratings of jet transport engines and could be used for lightplanes. It is also small and light enough to be mounted in the tips of copter rotors, he claims.

Gamma-radiating materials used to gage fuel tanks in NAA device

GAMMA RAY FUEL GAGE was developed for the Navy by NAA's Atomics International Div. The transistorized unit has been environmentally tested at altitudes up to 38,000 ft. All types of solid and liquid propellants can be measured by the gage, says NAA.

The gage uses atomic materials that are sources of gamma radiation, such as cobalt 60. These radiation sources are mounted on the sides of each fuel tank. The intensity of the gamma rays given off by the radioactive materials decreases as they pass through the fuel supply. A rate meter converts pulses picked up by the detectors into a dc voltage that is fed to an indicator displaying the quantity of fuel in pounds.

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PORTABLE ELECTRONIC TESTER for gas-turbine-driven APUs was developed by Electronic

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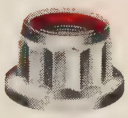

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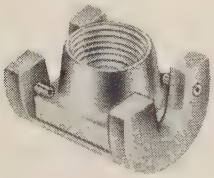

ESNA LH 2577T

ESNA LH 3849T

Photoelastic comparison of stress distribution patterns between standard self-locking nut and modified Elastic Stop nut using the Equa-stress thread form applied to a standard UNF-3 thread. Visual analysis reveals that the load is heavily concentrated on the lower three threads of the standard nut; in the Double Durability nut the load is re-distributed over all of the six threads below the locking device. Send for DESIGN MANUAL 5930 for additional photoelastic studies and illustrative drawings of stress distribution in fasteners.

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Write in No. 17 on Reader Service Card at start of Product Preview Section

Systems Development, a Solar subsidiary. The device which uses a logic computer, will check the complete circuitry of an airborne APU in about eight minutes, says Solar, including all switches, relays, and controls.

NEW METER STANDARD will be established by Bureau of Standards by the end of this year or early in '61. The present standard is a temperature-controlled bar of metal. The new one will be based on the wavelength of the orange light emitted by an atom of krypton 86. The measured meter will be equal to 1,650,763 wavelengths of the emitted light.

Bureau of Standards reports that the krypton standard is 10 times more accurate than the bar standard. With the latter, the best we could measure to was a millionth of an inch. Now it will be possible to measure one ten-millionth of an inch.

Several million pounds thrust from plug nozzle rocket is GE's goal

PLUG NOZZLE rocket studies by General Electric under a $400,000 NASA contract, are directed toward the development of a multi-million-pound thrust propulsion system. The design contains a number of cellular combustion chambers which can be designed and tested on a small scale and then be assembled to produce the desired thrust level.

COMBUSTOR SEGMENTS of the plug nozzle engine form a segmented annular combustor about the base of a conical spike, or plug. Unlike in conventional combustion chambers, much of the gas expansion takes place externally. The gas flow is confined only by the plug surface, since the outer jet surface remains a free boundary.

Supersonic gases expand as they flow along the conical plug surface until their pressure matches ambient conditions. In effect, the exhaust automatically adjusts itself to altitude, increasing the rocket's efficiency. According to Louis Michelson, manager of GE's rocket engine section, this higher efficiency would be most pronounced at low altitudes. As a result, he claims, the engine is particularly suitable for use in the first stage of a multi-stage vehicle.

•

MULTIPLE-CELL configuration of the liquid propellant plug nozzle engine will permit in-flight trajectory corrections by controlling the combustion pressure in the various cells. Thrust can be varied aerodynamically without moving the entire engine or using jet deflectors. With a rigid mounting between propulsion system and vehicle frame, GE says, you can make a significant saving in weight, space, and costs, since you don't need the usual gimbaling mechanisms and stress redistribution structures.

Reactor APU with external thermionic converters predicted for next 3-5 years

TIMETABLE for the development of nuclear APUs was spelled out by Sherman Naymark, of the GE's Atomic Power Equipment Dept., before a meeting of the American Astronautical Society:

- a radioisotope-thermionic converter putting out several hundred watts at five per cent efficiency in two years;
- a reactor with rotating turbine generator equipment in the 10-500-kw range and with 10-15 per cent efficiency in 3-5 years;
- a reactor with external thermionic converters in the multikilowatt range and with a five per cent system efficiency also in 3-5 years.

■

CRYOGENIC GYRO under development will be 5-10 times more accurate than competitive gyros, according to General Electric engineers. It is being developed by GE for the Army Ballistic Missile Agency.

The experimental design has a small metal ball, or rotor, that is kept at a temperature close to absolute zero in a vacuum environment. An electric charge sets up a magnetic field around the rotor to "float" it and keep it from touching the metal walls of the housing. Eventually, gas molecules in the imperfect vacuum produce drag and stop the rotation. The gyro then can be reactivated by another electric charge.

TEST ION ENGINE in operation for 50 hours at NASA's Lies Research Laboratories was powered by a three-kilowatt supply. According to J. Howard Childs, chief of NASA's Electric Propulsion Branch, the power input could probably be pushed up to 40 kw, and the engine would still work. With that much power, says Childs, you could adjust the trajectory of an orbiting satellite.

Pure cesium used in the test engine was consumed at the rate of 0.001 lb/hour at three kilowatts. Childs figures the rate would be close to 0.01 lb/hr at 40 kw.

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calendar

March 6-9—Gas Turbine Power & Hydraulic Conf., American Society of Mechanical Engineers, Rice Hotel, Houston, Texas.

March 9-10—Symposium on "Processing Materials for Re-Entry Structures," Midwest Chapter, Society of Aircraft Material & Process Engineers, Miami Hotel, Dayton, Ohio.

March 9-11—Conf. on the Mechanical Properties of Engineering Ceramics, North Carolina State College School of Engineering; Office of Ordnance Research, U. S. Army, North Carolina State College, Raleigh, N. C.

March 10-11—National Flight Propulsion Meeting (Secret), Institute of the Aeronautical Sciences, Cleveland, Ohio.

March 14-15—Symposium on Load-Carrying Capacity of Bearings, ASME Lubrication Div., Engineering Societies Bldg., Auditorium, New York, N. Y.

March 17-18—Synchro Design and Testing Symposium, Dept. of the Navy, Bureau of Naval Weapons, Dept. of Commerce Auditorium, Wash., D. C.

March 21-24—Institute of Radio Engineers' International Convention, Waldorf Astoria and Coliseum, New York, N. Y.

March 23-25—Symposium on Optical Spectrometric Measurement of High Temperatures, Univ. of Chicago's Applied Science Labs; Jarrell-Ash Co., National Science Found., University of Chicago, Chicago, Ill.

March 24-25—First Annual Symposium on Human Factors in Electronics, IRE Professional Group on Human Factors in Electronics, New York, N. Y.

March 29-31 — American Power Conf., ASME, Sherman Hotel, Chicago, Ill.

April 4-8—Fourth Colloquium, Combustion and Propulsion Panel, Advisory Group for Aeronautical Research & Development, NATO, Milan, Italy.

April 5-8—National Aeronautic Meeting & Missiles & Aircraft Engineering Display, Society of Automotive Engineers, Commodore Hotel, New York, N. Y.

April 6-8—National Meeting "Hyper-Environments-Space Frontier," Institute of Environmental Sciences, Biltmore Hotel, Los Angeles, Calif.

April 6-8 — Structural Design of Space Vehicles Conf., American Rocket Society's Structures & Materials Committee, Biltmore Hotel, Santa Barbara, Calif.

April 7-8—Annual SPI Western Section Conf., Society of the Plastics Industry, New Riviera Hotel, Palm Springs, Calif.

April 12-13 — 14th Annual Spring Technical Conf., IRE in conjunction with the ARS, Hotel Alms, Cincinnati, Ohio.

April 18-20—Symposium on "Chemical Reactions in the Lower and Upper Atmosphere," Stanford Research Institute, Mark Hopkins Hotel, San Francisco.

April 19-21—International Symposium on Active Networks & Feedback Systems, Polytechnic Institute of Brooklyn, Dept. of Defense Research Agencies, IRE, Engineering Societies Bldg., New York, N. Y.

April 20-22 — National Symposium on Manned Space Stations, NASA, the Rand Corp., IAS, Ambassador Hotel, Los Angeles, Calif.

April 21—Annual Eastern Regional Meeting, Institute of Navigation, Key Bridge Marriott Motor Hotel, Wash., D. C.

April 21-22—Southwest Metals & Mineral Conf., "Metals & Minerals for the Space Age," American Institute of Mining, Metallurgical & Petroleum Engineers, Ambassador Hotel, Los Angeles.

PICTURE CREDITS: Cover—S/A-Meyerriecks; pp. 42-44—Boeing Airplane; pp. 45-49—Stanford Research Institute, USN; pp. 50-54—S/A, Republic Aviation, Avco Mfg., General Electric; pp. 56-58—Convair; pp. 61-63—Hazeltine; pp. 87-98—Convair; pp. 122-128—Du Mont Labs.; pp. 127-129 USAF; pp. 141-146—Northrop; pp. 151-154—Wyeth.

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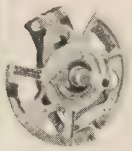
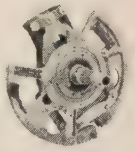

PITCH and ROLL CONTROL Regulator —left hand


PITCH and ROLL CONTROL Regulator— right hand

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Northrop's management tools for cost control

The trend general in the aerospace industry unquestionably is toward higher costs—inflation and increasing technical complexity see to that. Is there anything the industry can do to counter this trend?

by Robert M. Loebelson,
Associate Editor

THE DEFENSE DEPARTMENT wants a wide variety of weapon systems but has little money with which to buy them. Pentagon officials therefore are busily pointing out that the most efficient low cost producers will get more of the defense business. As a result, every company in the aerospace industry is searching for new techniques to reduce overhead and so become more competitive.

One of the oldest companies in the business has been a leader in trying out some novel cost-cutting techniques—Northrop Corp., whose president, T. V. Jones, has said that defense producers must concentrate on capability rather than capacity. Among the new methods this company has applied are:

- The Pace (*P*erformance *a*nd *c*ost *e*valuation) program, now two years old, and designed mainly to cut costs;
- "value analysis," a technique for controlling expenditures and so improving profits;
- a "target cost system," which determines whether a new system can be manufactured within given cost limits.

Pace is essentially a statistical method of measuring the effectiveness of a group in performing an assigned task. It differs from other industrial engineering techniques like time study and ratio delay study in measuring the effort of a group rather than of an individual. No stop watches or cameras are used—observation and random sampling provide the data for rating group effectiveness. The speed of the system is shown by the trained observer's activities: he covers about 750 people in his rounds several times a day.

In the Norair operation, a specially trained observer makes a basic two-week study of the department he will observe, learning about the department's tasks and explaining his role to departmental personnel.

After that, he tours the department several times daily, using different routes on a random schedule. He notes the number working, the number idle, those out of the assigned work area, and evaluates the group effort. He assigns an effort rating after comparing the operation with the established normal pace of efficient workers.

When Pace is used on office or technical groups, two major modifications are made:

- Since office functions often require personnel to be away from their posts, only abnormal out-of-area time is computed as a penalty.
- In observing office groups, there is no penalty for physical inactivity that is not clearly idleness. This is an effort to encourage thinking and give the office group the benefit of any doubt.

For factory activities, the observer's findings are translated into a basic Pace index with a formula that takes in the number of personnel assigned, the personnel on loan, idle, and out of area, and the effort rate. Every week this index is plotted on a chart.

Index should level off in the end

The goal is to raise the Pace index to 85-100 per cent of the normal optimum effort. Norair believes the index should climb steadily until it reaches this control area and then level off.

Norair uses the Pace index together with several other indices to get a better picture of a department's performance. The others include:

- the personnel index—the number of people doing a job should decrease as Pace improves;
- the budget realization index—the ratio of earned hours to actual hours worked;
- the schedule index—the ratio of actual to scheduled production;
- the quality index—quality tends to increase as Pace increases;
- the shortage index—the ratio of shortages to the total number of parts that should be available.

Norair has been using Pace since March 1958 with good results. It has been acclaimed by many industrial measurement authorities, including Dr. Ralph M. Barnes, UCLA professor of industrial management.

Northrop's second approach to lower costs and improved profits, value analysis, involves the evaluation of an item's function, relating its effect on the end product, and assigning an appropriate value. The value analysis concept, which holds that value is equal to the lowest price that must be paid to accomplish a required function, involves the thinking of a broad cross-section of the people involved in getting a product into operational service. Since Norair's value analysis operation cannot support all the people needed to do all the analyses, buyers, engineers, mechanics, suppliers, and others are called in to help.

Essentially, what value analysis tries to do is study potential design modifications without jeopardizing or compromising functional integrity or evaluate similar materials and test data to minimize qualification requirements. Northrop's experience has been that one out of six value studies has resulted in savings. Among the improved prices resulting from Norair's value analysis program are:

- A complete hinge assembly made from solid bar stock cost the company $85.61 each. When value analysis showed an extrusion should be equally effective, the company started buying the extruded hinge assembly for $50.95. Since 2164 hinges were purchased, the total saving was just over $75,000.
- Northrop had been buying rectangular plate stock for T-38 wing skins but discovered the mill would supply these wing skins rough-cut to shape for $97.18 less than the rectangular plate. The supplier who does the sculptoring could therefore reduce his price by $126, for a total saving of $223.18 on each skin. Each T-38 uses two wing skins, meaning that the total saving, if 1000 T-38s are built, would be $446,360.
- Even on such a small item as a stapler, the potential is good. Stapler A, originally used by Northrop, cost $3.03 and required special staples costing 90 cents a box. The company was paying $3030 for staplers and $495 for staples. But Stapler B, which would use any staple, cost only $1.95 and took staples costing 39 cents a box. The company started using Stapler B, at an annual cost for staplers of $1380 and $214.50 for staples. Total annual saving on this item was $166.50.

The Hawthorne company, though enthusiastic about the benefits of value analysis, has discovered that the program has a built-in hazard. Since the program involves change, and change runs against human nature, there is a natural tendency to distrust suggested innovations. In any firm that uses value analysis, there must be a willingness to overcome pride, biased opinions, and apathy.

Over half million dollars saved

Northrop's two-man value analysis team, which started operations last April, claims it can document savings totaling $496,430 on 63 T-38 supersonic trainers and at least $104,766 on other contracts. These savings were achieved even though the team has no authority to enforce its recommendations.

The third new approach at Norair is the target cost program on the N-156 supersonic fighter for NATO nations. This program is designed to provide a breakdown of the engineering, design, manufacturing and materials plans for predicting costs before fabrication starts and measuring costs as designs are completed.

Engineering drawings of the N-156F have been integrated with the manufacturing breakdown to set up a system of identifiable costs for each major section or section unit. The N-156F structure is grouped into six major sections (forward fuselage, center fuselage, fuselage, wing, aft fuselage, and final assembly) and 12 systems (electric, communications and navigation, fire control, instruments, equipment, landing gear, hydraulics and pneumatics, controls, armament, propulsion, heat and vent, and fuel).

Target costs usually remain fixed

The total target costs are determined from the original work statement, preliminary design information, and the statistical cost data used to determine the sales price of the weapon system. These target costs for the major sections and systems, which are related to the quantity on order, remain fixed and change only if the customer makes requests that drastically affect the original plan.

Norair then comes up with predicted costs for the section units. There are developed from data furnished by product plans and design engineers, primarily in the Manufacturing Program Planning and Materiel groups.

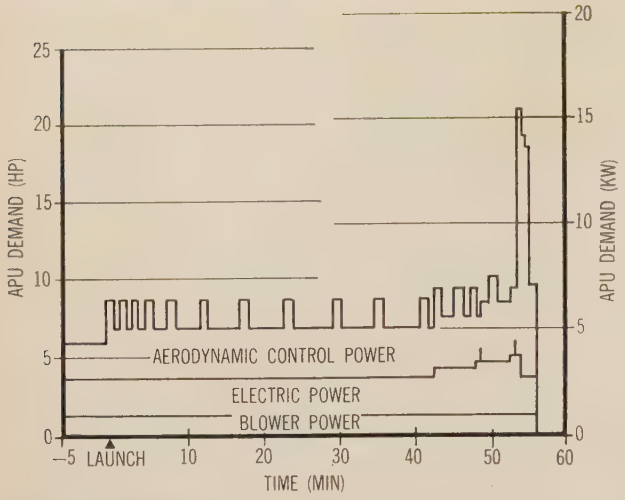
Adjusted predicted costs are determined after taking into account cost reduction, performance, weight, maintainability, and reliability changes. A continuous comparison is made between adjusted predicted costs and the predicted and target costs to check design progress. If the costs are above the original target, less expensive concepts may be tried. Alternatively, systems may be evaluated to determine what changes can be made to keep costs in line.

Calculated costs (determined from final released engineering drawings) apply only to production programs. These complete the cycle of the target cost program and serve as a detail check of Norair's ability to meet target costs. If these calculated costs are higher than the original target costs, some corrective action can again be tried.

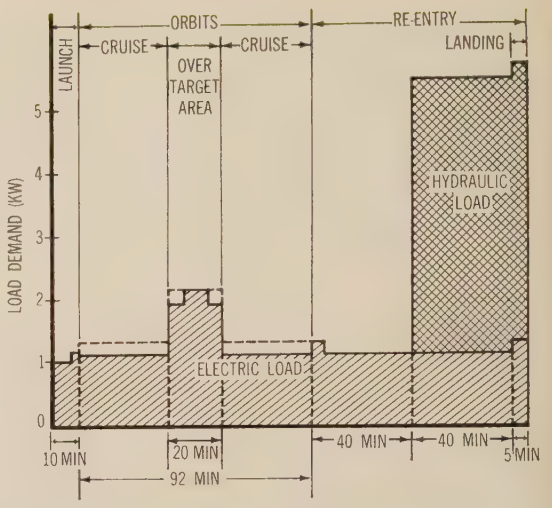
Final check point is the determination of actual costs for a prescribed number of production units. The actual costs are taken from labor time card charges and from the cost accounting department. This step demonstrates the ability of the Design, Manufacturing, Tooling, and Materiel Divisions to meet target costs.

Actual costs are not shown on master target cost charts (Norair considers them proprietary information), but the charts do show the target, predicted, adjusted predicted, and calculated costs for labor, materials, and development tooling for the N-156F. This master chart shows the costs for 34 structural section units, six major structural section groups, and the major section totals for the 12 systems. It serves to determine cost trends for specific sections of the lightweight fighter.

Master charts showing progress on both the prototype and the 1000th version of the production airplane are placed in design and project areas for continuous study. Smaller copies are distributed to manufacturing, materials, tooling, engineering, and management echelons each months to depict cost changes.—End



INTERCONTINENTAL glide missile will need about 10 hp to handle hydraulic loads, while some manned re-entry glide vehicles will need 20 hp for aerodynamic loads.



Boeing graph at far left shows power delivered in the operating equipment. It makes no allowance for losses in generation, distribution, and conversion, which may

Non-propulsive power

for advanced vehicles

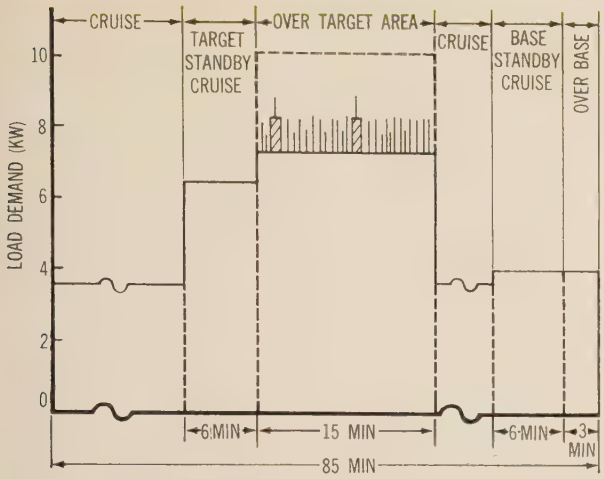
This is the first article in a three-part series on non-propulsive power systems. It reviews the factors that influence the choice among these systems, especially for missions beyond the atmosphere. Next month's article will analyze the available non-propulsive power systems.

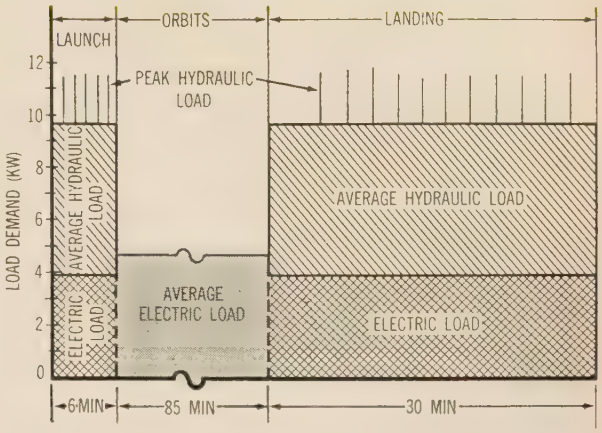
by Robert W. Curran, Senior Group Engineer, Physics Staff, Aero-Space Div., Boeing Airplane Co.*

REASONING does enter into the selection of non-propulsive powers systems (contrary to popular belief). The vehicle load profile is the most important factor. After it come such considerations as weight, volume, availability, reliability, shelf life, cost, and peculiarities of the application. However, often a normally "minor" consideration becomes so important—because of vehicle design or performance limitations—that it turns into a decisive factor. In effect, the vehicle designer wants the lightest non-propulsive power system that can be delivered on time and is easy to install—at minimum cost to the vehicle system.

Sometimes the evaluation can become quite complex. Economics, for example, go far beyond the cost of the hardware installed in the vehicle. Many power systems

* Aerospace Div., Boeing Airplane Co., P.O. Box 3707, Seattle 24, Wash. This series is a condensation of a paper, "The Applicability of Nonpropulsive Power to Space Vehicles," given at the Vickers Aircraft Hydraulic Conference in Detroit, Mich., last November.





come to 30-40 per cent of the generated total. Center left: Load profile for an unmanned surveillance vehicle on a 30-day mission involving 468 orbits. Center right: Load profile for a manned recon vehicle making up to nine orbits per mission. Far right: Electric load for the orbital part of such a mission.

that a designer would like to use have not been reduced to flyable hardware yet. So the vehicle he is working on would have to be charged with the full development cost of a non-propulsive power system that might eventually be used in several other vehicles, too.

What does this mean in dollars? The development cost of a chemically fueled system would probably run to about $5.

Sometimes it is possible to offset high development costs with the launch-cost saving resulting from reduced system weight. For example, it may cost $500 or more a pound to place equipment in orbit. If 100 launchings are involved, a saving of 100 lb in equipment weight saves $50,000 per launch or $5 million over the life of the weapon system.

The mission provides the most important criteria for deciding on the type of non-propulsive power system that is to be used. Will the vehicle be manned? At what altitude will it operate? Will it re-enter? Must it operate while shadowed from the sun?

Whether or not the vehicle is to be manned is particularly important when you deal with nuclear energy sources. It can take up to four times as much shielding weight to protect men as it does to protect sensitive equipment.

Altitudes become important when you consider large radiators or solar-energy collectors. Drag can be appreciable at altitudes of 100-200 nm. The thrust to offset this drag is chargeable to the non-propulsive power system. In one case studied by Boeing, an 18-kw chemical (hydrogen-oxygen) power system operating at 100 nm altitude was as good as an equivalent solar power system once you took into account the cost of making up for the drag of the solar-cell array.

Closed-cycle power systems using a radiator face a problem during re-entry, for the aerodynamic heating reduces and sometimes cancels the effectiveness of the raditor. Open-cycle chemical systems do not have this problem. In fact, some hydrogen-oxygen systems use aerodynamic heat to generate useful power.

The large collector devices on solar power systems (e.g., 250 sq ft/kw for a silicon solar cell suitable for orbital flight) cannot take aerodynamic re-entry loads while extended. Extra power equipment therefore must be installed to handle the normally high re-entry power demands.

Because of the radiation hazard the re-entry of a nuclear non-propulsive power system poses the most difficult problem. In space, where there is no atmosphere, the crew can be protected by a shadow shield, since there is no radiation scatter. During re-entry, there *is* scatter, so the reactor will have to be shut down several hours in advance. Again, an extra energy source must be used (during shutdown and re-entry).

Re-entry weight imposes penalty

Re-entry weight may also penalize certain power systems. Equipment that uses an expendable fuel will re-enter at a much lower weight than fixed-mass systems like the solar, nuclear, and battery types. Reduced weight means lower aerodynamic control forces during re-entry and lower structural temperatures.

Attitude stabilization in orbit must be considered, particularly if the vehicle is to use a solar power system. If the vehicle is to face the sun at all times, the solar collector can be fixed. But if the vehicle must always face the earth or is allowed to tumble randomly, the solar collector must be oriented independently of the vehicle. For maximum efficiency, the collector should have 360 deg of freedom about two axes. An alternative would be to place enough cells over the surface of the vehicle or on paddles to provide power regardless of attitude. This is fine for low power levels but costly for higher levels.

more on next page

Power Requirements

	Required Power (W)
Guidance	
Inertial platform and associated electronics	750
Star tracker	100
Horizon seeker	15
Radar altimeter	150
Radio guidance	200
Automatic landing	50
Secondary attitude reference	200
Doppler radar	500
Beacon	50
Communications	
Voice	250
Telemetry (14 channels)	25
Flight Control Electronics	300
Emergency Rescue Equipment	
Beacon	10
Transceiver	10
Flasher	10
Crew Accommodations	
Lighting	50
Cockpit instrument display	150
Food preparation	500
Pressure suit	50
Environmental Conditioning	
Blower	*
Controls	
Manned	50
Unmanned	10
Reconnaissance	
E-2 Elint	750
Photographic equipment	325
Infrared	50

* Blower power will equal about 10 per cent of the vehicle heat load.

The effects of mechanical power systems using rotating or reciprocating parts on vehicle orientation cannot be neglected either. All improperly balanced mechanical equipment will lead to an orientation-system weight penalty. In this respect, static power generating systems (e.g., fuel cells) look quite attractive.

Some vehicles under consideration will have added value if they are difficult or impossible to detect by such means as radar or infrared. Unfortunately, power generating systems generally involve the use and disposal of heat. Some systems, however, are more easily detected than others. For example, the radiator in a closed-cycle power system makes a better infrared target than the exhaust from a hydrogen-oxygen engine. And a vehicle with a large solar collector is easier to locate by radar than the same vehicle if it uses a chemical energy source.

Equipment growth also enters into the selection of a non-propulsive power system. Some of our present space craft are designed for limited application, and there's little or no thought of producing improved models. As more complex systems evolve, though, this attitude will change. It will be necessary to select prototype power equipment whose output and life can be increased without major redesign. Considerations like this one will gradually rule out the battery in favor of a hydrazine APU, and the hydrazine design in favor of a cryogenic engine, and so on until we end up with a nuclear power system.

Environment is also important. Space operation means the non-propulsive power system will have to work in zero gravity for long periods. Special attention must be paid to such problems as fluid expulsion from tanks, chemical reaction in batteries and fuel cells, lubrication of mechanisms, and boiling or condensing of fluids. Zero gravity must prevail or a localized gravity effect must be created. Naturally, the performance of a static device like a silicon solar cell is not affected by gravity. In fact, under weightless conditions, large arrays may be extended quite easily without elaborate structure or mechanisms.

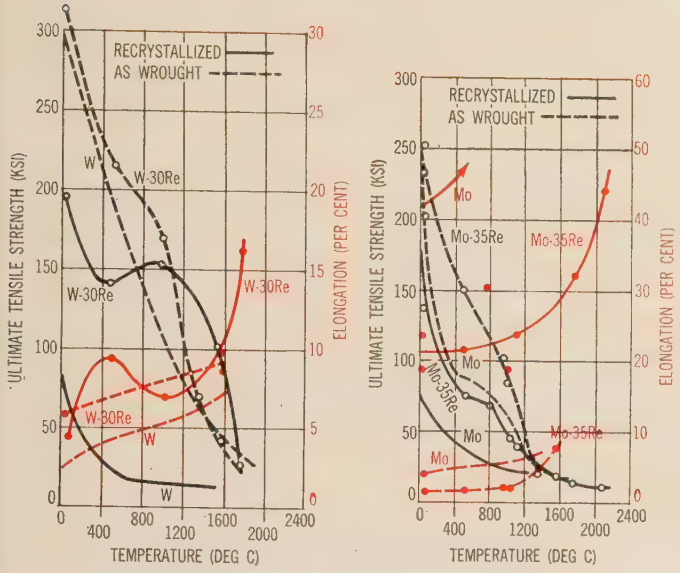
Effects of hard-vacuum operation

Operation beyond the earth's atmosphere will place the vehicle in a hard-vacuum environment of 14.5×10^{-12} psi. Undoubtedly, this vacuum will have adverse effects on the operation of non-propulsive power equipment. For example, what will happen to special mirror or radiation surfaces treated for high reflectivity or high emissivity? Will these special surface characteristics be lost after a period of exposure to a space vacuum? Can we join solar cells to a honeycomb structure and expect the integrity of the bond to remain unaffected? Can an inflatable structure be used to extend a solar collector in space? One advantage of a hard vacuum is that open-cycle expansion engines can be operated on an infinite choice of pressure ratios.

The designer of the non-propulsive power system must also remember that all the energy delivered by his system will be converted into waste heat within the vehicle. This heat must be dissipated either by direct radiation or by transfer to a fluid that, in turn, is dumped overboard.

The importance of equipment volume and shape depends on the vehicle configuration. For example, the booster-vehicle interstage of most lunar vehicles can readily take the large volume of a hydrogen-oxygen power system. The problem of providing storage space for a solar cell array in the same vehicle is much more involved. Although the volume is smaller, the cell array must be packaged so that it can be easily extended. Usually a long channel is needed that is open at one end and runs down the center of the vehicle. Such a layout interferes with the general equipment arrangement and complicate the structural design.

The extension of large radiators poses another problem that must be resolved with the help of vehicle designers. The radiator of a nuclear non-propulsive power system must be retracted into the vehicle for launch and re-entry and must be extended into the safe-zone shadow of the reactor shield at other times.—End



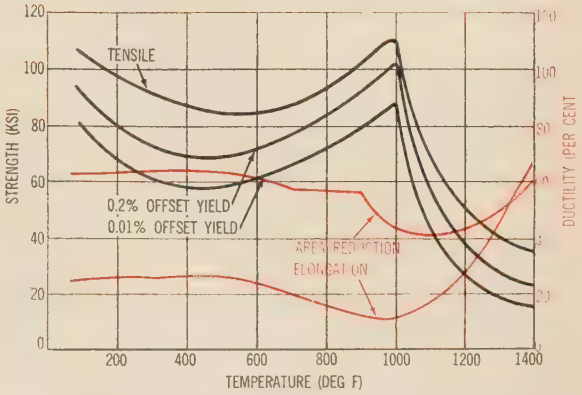


FIGURE 1: Effect of rhenium addition on the properties of tungsten and molybdenum (left). The 50W-50Re alloy is also being studied by several researchers. Above: Tensile properties for forged and heat-treated 50Cr-50Fe as reported by A. K. Wong. The strength-curve minima and maxima at 50 and 1000 deg F, which were also found for 40Cr-60Fe, are unexplained so far.

State of the art:

chromium and rhenium

Refractory metals are prime candidates for solving the high temperature problems of upcoming aerospace vehicles. In its continuing coverage of these materials, S/A here reviews the latest data on two of the most recently studied refractories.

by Jess W. Wilson, Metallurgist,
Stanford Research Institute

THE PROPERTIES that make chromium so attractive for high temperature applications are a relatively low density of 7.2 gm/cc, a melting point of 1900 deg C (3450 F), which is about 720 deg F above that of nickel and cobalt, relatively good oxidation resistance, and abundance. Limitations of chromium for very high temperature use are a relatively low melting point compared with other refractory metals, like tantalum, tungsten, and columbium and lack of ductility below around 300 deg C (570 deg F).

The mechanical and oxidation properties of unalloyed chromium have been fairly well evaluated. A vast amount of research had been done on the mechanical properties of chromium alloys. Because of the ductile-brittle behavior of the metal and the sensitivity of this property to many factors, correlation of the resulting data is difficult. Several developmental alloys that we will discuss here show promising creep rupture proper-

* Stanford Research Institute, Menlo Park, Calif.

more on next page

Table I:

Room-Temperature Tensile Data for Annealed Rhenium*

	Specimen[1]	Specimen[2]	Specimen[3]	Average
Modulus of Elasticity (psi)	72.6×10^6	65.9×10^6	65.8×10^6	66.7×10^6
Proportional limit (psi)	35,100	26,800	18,100	26,300
Yield strength (psi)				
0.1 per cent	50,600	44,000	31,500	42,000
0.2 per cent	55,200	49,500	35,000	46,000
Ultimate tensile strength (psi)	168,000	164,000	161,000	164,000
Elongation (in ½ in., per cent)	24.6	22.0	25+	24
Area reduction (per cent)	24.1	20.1	21.1	2.17
Shear modulus (psi)	22.6×10^6			22.6×10^6
Poisson's Ratio	0.49			0.49

*From Sims et al, Battelle Memorial Inst. Tests run on 0.15-in. rod swaged from sintered bar.

Tensile and Elongation Data for Annealed and Cold-Rolled Rhenium Sheet*

		Reduction (per cent)		
	Anneal	12.9	24.7	30.7
Rolled thickness (mils)	10.1	8.8	7.6	7
Proportional limit (ksi)	31.7	25.2	42.2	159
Yield strength (ksi)				
0.1 per cent offset	131	233	279	282
0.2 per cent offset	135	245	298	311
Ultimate tensile strength (ksi)	168	250	307	322
Elongation (in 1 in. per cent)	28	8	2	2
Area reduction (per cent)	30	24	1	1

*From Sims & Jaffee, Battelle Memorial Inst. Tests run on standard 0.2-in.-reduced-section, one-inch-gage-length sheet.

Table II:

Stress-Rupture Data at 1800 Deg F for 81Cr-16Mo-3Si*

Stress (ksi)	Life (hr)	Elongation (per cent)	Area Reduction (per cent)
16	790		6.3
18	368	6	7.5
22	231	0.12	3.6
26	256	3.8	0.251

*From data by Silverman, WADC-TR-53-190, Part 4, AD 93172.

Table III:

Room-Temperature Tensile Data for Annealed, Thoriated Rhenium[1]

	Thorium Content (as ThO_2, per cent)			
	0[2]	0.5	1	2
Proportional limit (ksi)	26.3	23	27	22.9
Yield strength (ksi)				
0.1 per cent offset	42	39.6	42.4	42.4
0.2 per cent offset	46	44.7	47.6	
Ultimate tensile strength (ksi)	164	144	135	137
Elongation (in ½ in. per cent)	24	14	11	14
Area reduction (per cent)	21.7	16	16	16

(1) From Sims et al. Tests run on 0.15-in-diameter swaged rod with ⅛-in.-diameter reduced section. (2) Averages of three values.

ties—better than those of commercial alloys based on cobalt and nickel—at 1800 deg F and higher.

Chromium alloys thus potentially extend the upper useful temperature range several hundred degrees F beyond today's super-alloys. However, success in this direction depends on solving the low temperature ductility problem and further improvements in oxidation resistance. *Figure 4* plots the modulus of elasticity of chromium and some alloys against temperature. *Figure 3* shows the metal's high temperature tensile properties.

The high temperature at which the transition from ductile to brittle behavior occurs has bedeviled every study of chromium's mechanical properties. Five variables have been shown to effect the transition temperature or its determination:

- impurity content and distribution of interstitial and metallic elements;
- microstructure as produced by fabrication and/or thermal treatment;
- the stress system induced by bend, torsion, compression, tension, impact, and hardness tests;
- the strain rate of the test procedure;
- the test specimen surface condition.

Studies by Maykuth and others show that a decrease in N_2 impurity content greatly improves the ductility of unrecrystallized material. Studies by Weaver show that the transition temperature depends on the amount of nitrogen that is present. In strainage hardening tests, precipitated particles appeared in the microstructure when the nitrogen content was 0.1-0.005 per cent, but not when it was 0.0015 per cent or less. Recrystallized chromium has been shown to have an inherent transition temperature of around 350 deg C by Wain, Henderson, and Johnstone.

Ductile-brittle transition tested

The effect of various binary alloy additions on chromium's ductile-to-brittle transition behavior in bend tests has been studied by Sully and Abrahamson and Grant. While several additions have been observed to decrease the transition temperature at high alloy contents, only ruthenium causes an immediate decrease. Studies on ternary alloy additions by Fountain and Lament show that manganese, cobalt, nickel, tungsten, molybdenum, and vanadium all decrease the transition temperature below 180 deg C for the 50Cr-50Fe alloy. Cr-Fe alloys containing 0.5-0.75 tantalum and 0.1-0.2

Stress-Rupture Data for 0.05-in-Diameter Rhenium Wire*

Temperature (deg F)	Breaking Stress (ksi)	Rupture Time	Elongation (per cent)	Remarks
68		100 hr	9.8 (in 1.5″)	ceased operation without rupture
930	105			ruptured during loading
930	90	2 sec		
930	75	3 min		
930	65	3.2 hr	5.6 (in 1″)	
1830	80	30 sec	2 (in 3.1″)	
1830	70	40 sec	2 (in 3.1″)	
1830	60	5 min	2 (in 3.1″)	
1830	50	3.7 min	2 (in 3.1″)	
1830	40	16.5 hr	2 (in 4.6″)	
2730	9.5	19 min	0 (in 2.3″)	oxidized badly
2730	9.5	41 min	3 (in 1.2″)	oxidized badly
2730	9.5	4.6 hr	1 (in 2.5″)	no oxidation, good test
3630	1.1	23 min		oxidized badly
3630	1.1	48 min	0.5 (in 3″)	oxidized badly
3630	1.1	12.3 hr	4.4 (in 2.5″)	no oxidation, good test

*Data from Sims & Jeffee. Tests run in helium atmosphere containing five per cent hydrogen.

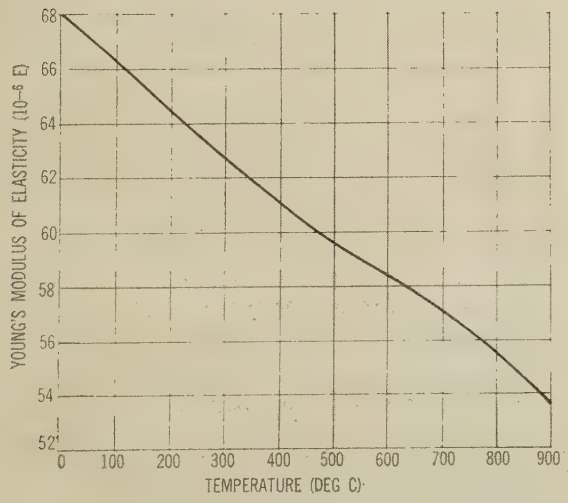
zirconium, it appears, have the lowest impact transition temperature—about 50 deg C.

Table IV shows the results of studies by Nelson and Anderson on the effect of heat-treat time and temperature on room temperature tensile properties of various Cr-Fe alloys. The highest ultimate tensile strength (UTS) was obtained from a specimen from the ingots in the as-hot-rolled condition—146,400 psi from a 60Cr-40Fe alloy rolled at 750 deg C. The next test, of another alloy of the same nominal composition and work history, showed a slightly lower UTS of 139,900 psi, but a ductility of 15 per cent as against only six per cent for the earlier test. The ingot from which the second test specimen was prepared, it was stated, contained less oxygen than any of the others tested. *Table IV* makes clear that proper working and heat-treating methods are necessary for optimum mechanical properties in Cr-Fe alloys.

Added ternary tungsten looks good

Work by Maykuth and others shows that the use of a ternary addition of tungsten appears to hold the greatest promise for improving the room temperature mechanical properties of Cr-Fe alloys. The alloy that best combined good strength with ductility was 55Cr-35Fe-10W, which had a tensile strength of 130,000 psi, a yield strength of 102,000, 16 per cent elongation, and 26 per cent area reduction.

Studies of ternary Cr-Fe alloys by Kate and Hayes showed a 60Cr-37Fe-3Ni alloy offered the best combination of room temperature tensile strength and elongation: 164,500 psi and 16 per cent. The improved tensile strength of this Bureau of Mines alloy over the Battelle's 55Cr-35Fe-10W is probably due to differences in fabrication methods. Battelle combined high purity with adequate work to produce a ductile, fibrous-grained



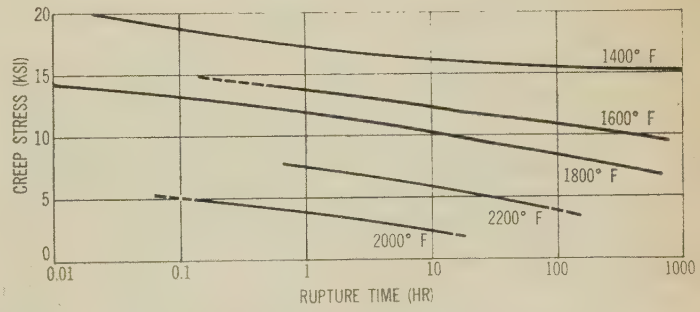


FIGURE 2: Temperature vs modulus of elongation (left) for rhenium. Above: creep-rupture properties of Chromium as reported by J. W. Pugh are the result of the first extensive study of this parameter.

Table IV: Room-Temperature Tensile Properties of Some Heat-Treated Cr-Fe Alloys[1]

Cr Content (per cent)	Heat Treatment		0.2% Offset Yield Strength (ksi)	UTS (ksi)	Elong. (per cent)
	Time (hr)[2]	Temp (deg C)			
50[3]	HR	950	100.8	106.5	16
50[3]	HR	950	104	110	16
60[4]	4	950	91	111	4
60[4]	4	950		75.2	0
65[4]	4	950		57.6	0
70[4]	4	950		34.8	0
60	4	950	103.6	118.3	14
60	4	950	131	118.2	13
60	1	875	108.2	133.1	4
60	2	950		118.5	6
60	6	950	142.3	45.2	0
60	HR	750	111.2	146.4	6
60	1	875		116.1	11
60	2	950	104.6	113.6	4
60	6	950		53.9	0
60	1	875	118.2	120.1	4
60	2	950	109.4	117.1	3
60	6	950		55.2	0
60	HR	750	134.4	139.9	15
60	HR	750	136.5	141	15
60	1	875	117.5	119	17
60	HR	750	133.3	135.4	10
60	CR		131.1	133.8	8
60	1	875	108	117.3	15
60[5]	2	950		67.9	0
60[5]	6	950		46	0

Stress Rupture Data for Cr-Fe Base Alloys at 1650 Deg F in Tension

Alloy Addition (per cent by weight)	Stress (psi)	Time to Rupture (hr)	Elongation at Rupture (per cent)
10 Fe, 10 Ta	26,880	55.3	1.2
10 Fe, 10 Ta	26,880	232.3	2
10 Fe, 10 Ta	26,880	23.7	
10 Fe, 10 Ta	26,880	19.7	2
10 Fe, 10 Ta	26,880	32.5	3.3
10 Fe, 10 Ta	33,600	19.1	0.7
10 Fe, 10 Ta	33,600	31.0	5
10 Fe, 10 Ta	33,600	32.4	9
10 Fe, 10 Ta	33,600	33.0	2.2
10 Fe, 10 Ta	33,600	22.6	2.2
10 Fe, 10 Ta	26,800	58	1.5
10 Fe, 10 W	20,160	5	0.7
10 Fe, 10 W	33,600	0.3	1
15 Fe, 25 Mo	33,600	45	4.5

(1) Data from Nelson & Anderson, U. S. Bureau of Mines Report 5107 for test specimens 1/16 in. thick and 1/4 in. wide at one inch gage length, unless otherwise noted.

(2) At annealing temperature after hot-working and before water quenching. HR indicates hot-rolling with no subsequent heat treatment CR indicates cold-working with no heat treatment.

(3) ASTM standard 1/8 in. round specimen.

(4) ASTM standard 1/4 in. round specimen.

(5) 0.76 per cent titanium added to binary Cr-Fe alloy.

structure; the other alloy had higher impurities and was in an extremed worked condition.

High temperature creep programs show that alloys with 10-15 per cent iron all have about the same creep resistance; increasing the iron to 20-31 per cent, however, drastically cuts creep resistance. Increasing the cobalt from 12 to 18 per cent decreases creep resistance; a further increase to 28 per cent improves the creep properties. Increasing the nickel from five to 19 per cent improved the creep resistance, but both nickel and cobalt alloys still had poorer properties than the 10-15Fe alloys.

Stress rupture studies at 1600 and 1800 deg F by Hevekotte, Greenridge, and Cross show that 15Fe-25Mo-2Ti alloys have rupture times of more than 1000 hours at 1600 deg F and 40,000 psi and more than 100 hours at 1800 deg F and 25,000 psi. Even though there was considerable scatter in the data for different tests, the best results were quite encouraging, since they were above the 100-hour stress-rupture strength of the best commercially available alloys. Studies by Silverman on an 81Cr-16Mo-3Si alloy shows a 1000-hour stress-rupture strength at 1800 deg F of about 15,000 psi (*Table II*).

The oxidation characteristics of unalloyed chromium were reported in 1952 by Gulbransen and Andrew. These researchers concluded that, up to about 900-950 deg C, the oxide film is adherent, but then flakes off on cooling. They believe this effect is related to the fact that, below about 950 deg C, the rate of evaporation is lower than the rate of oxidation, whereas at higher temperature the reverse is true.

The most extensive evaluation of the oxidation properties of chromium-base alloys was made by Abrahamson and Grant, of MIT. They tested the resistance to oxidation at 1800 deg F in flowing air of binary alloys containing titanium, vanadium, manganese, iron, cobalt, nickel, zirconium, columbium, molybdenum, ruthenium, rhodium, palladium, tantalum, rhenium, iridium, and platinum. With the exception of iridium, all these alloys at first increased chromium's oxidation resistance 3-15 times (as determined by weight-gain measurements). However, the best alloys still had poorer oxidation resistance than Nichrome.

The rhenium properties that are of particular interest are the melting point of 3180 deg C (5760 deg F) and the mechanical properties. Rhenium's hardness decreases only slightly from room temperature to 1470 deg F,

whereas most refractory metals suffer a large decrease in hardness over this range. Rhenium's main limitation for high temperature use is its extremely poor oxidation resistance. The oxide that forms (Re_2O_7) has a melting point of 297 deg C (570 deg F), which seriously restricts the metals at high temperatures (except in an inert atmosphere).

Practically all the available mechanical property data on rhenium have been reported by Sims and others at Battelle (*Fig. 2 & Table II*). The rhenium they used was prepared either from a highly purified ammonium perrhenate (and then ball-milled and reduced to metal with hydrogen) or by decomposition of a rhenium halide on a tungsten wire at high temperatures. Studies of the effect of work-hardening on the room temperature tensile properties of rhenium sheet show that 30 per cent reduction more than doubles the yield and ultimate tensile strengths and gives large decreases in elongation and area reduction as well.

Studies of the effects of one-hour annealing treatments on the hardness of different cold-worked specimens show that very little recovery occurs up to about 800 deg C and that nearly complete recrystallization occurs for all cold-worked states, except for a 10 per cent reduced metal, after one hour at 1300 deg F. It has been shown, though, that, for the purpose of cold fabrication, hardness must be brought below about 300 VHN, which usually requires anneals of two hours at about 1700 deg C.

Very few data are available on the effects of alloying addition on rhenium's mechanical properties. *Table III* gives data on the effect of additions of ThO_2 on room temperature tensile properties.

Additions of rhenium to Mo and W

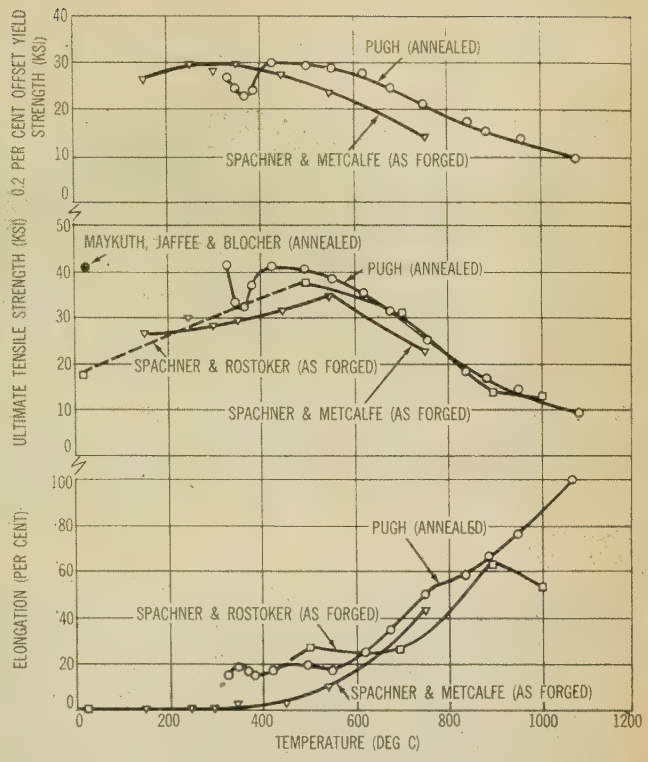
Particularly interesting is the recent work by Geach and Hughes on the effect of additions of rhenium to moylbdenum and tungsten. The rhenium was specified as 99.94 per cent pure. The 50Re-50Mo alloy was so ductile that it could be rolled at room temperature to more than 90 per cent reduction without any intermediate annealing. These studies also show that 30-35 per cent rheniums give the best maximum room temperature workability for the Re-W alloys that were considered.*

As a result of this work, Sims and others evaluated the properties of tungsten and molybdenum alloys with 30 and 35 atomic per cent rhenium, respectively. Tests were run in a helium atmosphere containing 2-5 per cent hydrogen (*Fig. 1*).

Battelle studies show that rhenium is hot-short when worked in air, regardless of the purity or type of the hot-working that is used. The trouble is believed to lie in the penetration of the grain boundaries by Re_2O_7.

As shown by the tensile data, rhenium has excellent room temperature ductility, and satisfactory cold-work methods have been developed and reported by Sims' group. The most successful method consists of rolling or pressing sintered bar material in steps of 1-3 per cent reduction, followed by a ½-hour hydrogen anneal at 1700-1800 deg C until a reduction of 10 per cent is achieved. In the later stages, 10-20 per cent reduction can be used per pass, followed by 1-2 hour of hydrogen anneals at 1700-1800 deg C. Similarly, sintered rhenium bar swages well.—End

* Alloy percentages by weight.


ULTIMATE TENSILE STRENGTH (KSI) 0.2 PER CENT OFFSET YIELD STRENGTH (KSI)
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SPACHNER & METCALFE (AS FORGED)
MAYKUTH, JAFFEE & BLOCHER (ANNEALED)
PUGH (ANNEALED)
SPACHNER & ROSTOKER (AS FORGED)
SPACHNER & METCALFE (AS FORGED)
PUGH (ANNEALED)
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FIGURE 3: Tensile properties for electrolytic chromium. Comparable data on iodide chromium are not available.

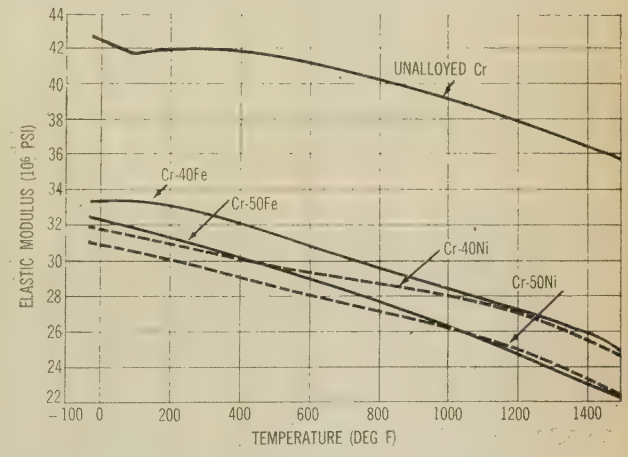
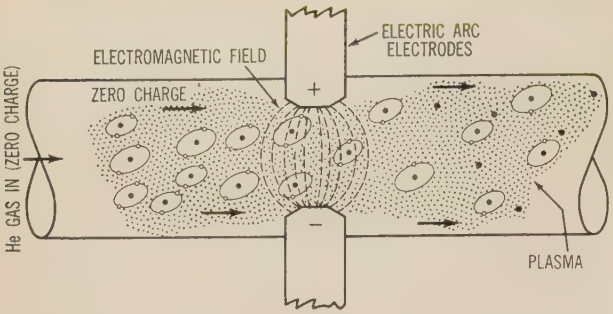
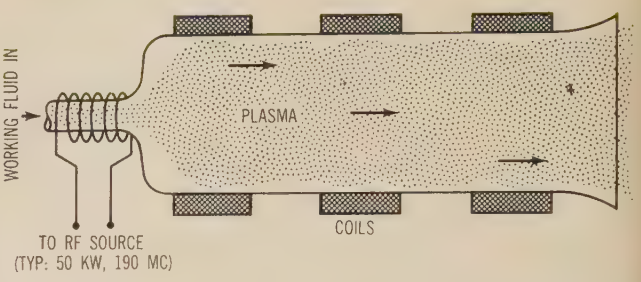


FIGURE 4: Temperature vs modulus of elasticity for unalloyed (iodide) chromium and some chromium alloys. The anomalous dip in the unalloyed-chromium curve at 100 deg F apparently increases with the magnitude of impurities and can be eliminated by alloying.





IN BASIC PROCESS of plasma generation (left), thermal, electric, and magnetic forces set up by the arcs rip at least one electron loose from the helium atom. Right: In "induction" plasma generator, coils produce magnetic fields that are phased as in a linear electron accelerator and exert pinching and accelerating effects.

How close is a practical plasma rocket?

With this article, S/A begins a series on electric propulsion, a field in which blue-sky speculation has run rampant for some time now. The result has been a lot of confusion—which these articles are designed to help untangle, answering such questions as: What is and what isn't electric propulsion? How far away is electric propulsion? What will it be able to do once we have it?

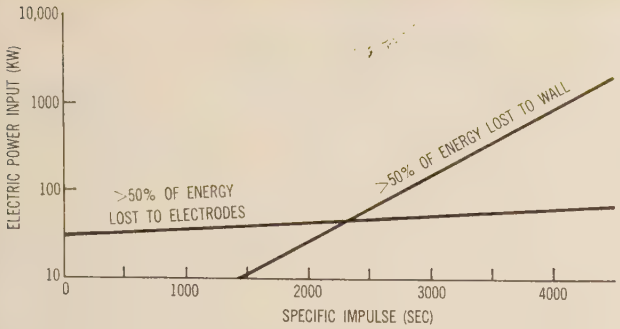
by Kurt R. Stehling,
Contributing Technical Editor

EXACTLY WHAT IS plasma propulsion? It is a special case of electric rocket propulsion. The latter differs from chemical, or "thermal", propulsion in that the working fluid is not heated by combustion but rather is electrically dissociated and heated, magnetically or electrostatically accelerated, and expelled through "throat and nozzle." The working fluid may be either a cloud, or "gas", of particles of the same charge, or a mixture of particles of different charges. When such a mixture contains an equal number of positive and negative charges, or ions and electrons, and these are uniformly distributed, its space charge is zero,* and we speak of a plasma.

To produce a plasma, the working fluid normally is pumped through an electric arc that can give temperatures of more than 3500 deg F. As the fluid passes through or between the arc electrodes, it is dissociated. The resulting plasma is neutral in terms of electric charge as sensed by an observer. The plasma next is pumped through an orifice into an accelerating device. In the electromagnetic field of the accelerating device, the plasma is accelerated in accordance with the familiar rocket momentum principle, and thrust results and acts on the body ejecting the plasma.

Under different names, plasma arcs or generators have actually been in use for quite some time. The atomic hydrogen-arc torch and certain types of electric-arc and high temperature gas-arc metal spraying devices

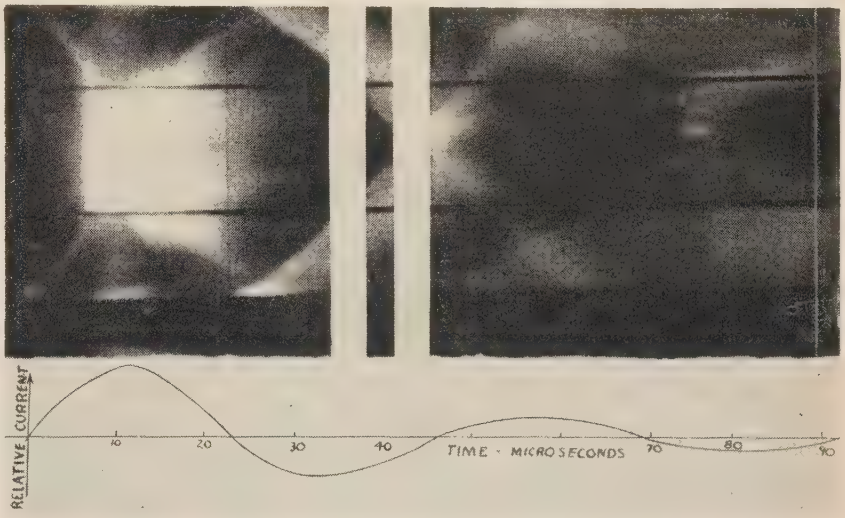
* A "space charge" denotes the accumulation in space of particles of the same charge. Such an accumulation tends to limit the number of particles that can be "squeezed" into a given volume. In the case of plasma, this problem does not exist, since there is no excess of particles of either charge and the space charge is zero.



AT LOW plasma densities, there are thrust, or efficiency, losses due to viscous dissipation at the duct walls and interaction with the electrodes.

Table I: Ionization Potentials of some Working Fluids (ev)

Element	Atomic Number	Ionization Stage		
		I	II	III
Hydrogen	1	13.595		
Helium	2	24.58	54.4	
Lithium	3	5.39	75.619	122.42
Beryllium	4	9.32	18.206	153.85
Nitrogen	7	14.54	29.605	47.864
Cesium	55	3.893	25.1	



"STREAK" photograph taken by Republic researchers of the pinching of a plasma. The plot of current vs time shows the "wringing" of the gas.

in a loose sense were early plasma generators. In certain re-entry studies in high density hypersonic wind tunnels, the reactions occurring at the boundary near the leading edge of the test body are in the plasma domain.

Under Project Sherwood, sponsored by the Atomic Energy Commission, considerable research has been done on self-sustaining nuclear fusion using a deuterium plasma. The Sherwood researchers hope to develop a practical nuclear fusion device in which plasmas are ignited at temperatures of many millions of degrees. They have come up with many methods for the pinching, or "squeezing", and reflection of plasmas and devoted much of their efforts to the stabilization of low density plasmas within electric and magnetic fields.

Choice of working fluid is first

The designer of a plasma rocket must begin by choosing a working fluid that is readily dissociated in an arc, has a low dissociation constant, can be stored for long periods without corroding its containers, and is stable. This fluid, incidentally, can be provided by a material that originally is a solid. Lithium, for instance, can be used in its solid state.

During dissociation, energy is put into, or added to, the working fluid. If the plasma from this fluid recombines during expansion or acceleration in the nozzle (i.e., if the ionized atoms or molecules recombine their ions and electrons), further heat is released and extra propulsive energy is produced by the exhaust jet. If the dissociated species do not change or recombine as they flow through the nozzle, and expand into space relatively unchanged, we have what is called "frozen flow"—the least efficient method of using the energy of expanding gas. The lower the plasma and exhaust gas temperatures, the lower are the losses from frozen flow.

Magnetic fields accelerate plasma

Magnetic fields are needed for accelerating the plasma. Because of the danger of losses from frozen flow, the acceleration should not heat the plasma to extreme temperatures. The magnetic fields of a plasma engine can also be used to contain or pinch the plasma; in this way, losses to the walls, electrode erosion, and heat transfer are reduced at the same time that the plasma is accelerated.

Acceleration and containment can be done with an

more on next page

TEMPERATURE of plasma jet developed by Avco is measured with sound pulses from quartz probes extending into the plasma flame. The small plasma generator has developed measured temperatures of more than 12,000 deg F.

Table II: Plasma vs Chemical Propulsion for 24-Hour-Orbit, 5,000-Lb-Payload Communications Satellite

Propulsion Systems	Propellant	Specific Impulse (sec)	Payload Weight Ratio	Propellant Weight Plus 10 Per Cent Tankage (lb)	Launch Weight (lb)	Flight Time (hr)	Remarks
Chemical	H_2-O_2	350	0.267	13,750	18,800	4	Hohmann transfer ellipse two stages.
		400	0.318	10,720	15,700	4	
Plasma	Li	2000	0.765	1540	6540	28	Power supply amounting t half payload weight, 50 l kw, included in payloac 50 kw thrust power.
		5000	0.898	570	5570	64	
		10,000	0.948	280	5280	131	

expanded horn or nozzle similar to the nozzle of a chemical rocket. Such a physical device, however, would not really be necessary in the vacuum of space.

If a magnetic and an electric field are used in combination to accelerate the plasma, the latter will be better contained, and the acceleration of the ions and electrons will be more nearly uniform. Much research is still needed on the complex interaction of ions and electrons with an external electromagnetic field. Because the electrons in a plasma are much lighter than the ions, they will oscillate if the plasma's neutrality of charge is disturbed in any way (as by an impressed magnetic field that induces an electric current and counterfield in the plasma). The displaced electrons will go through simple harmonic motions about their equilibrium positions. The frequency of these oscillations is given by:

$$f^2 = ne^2/m_e q_o,$$

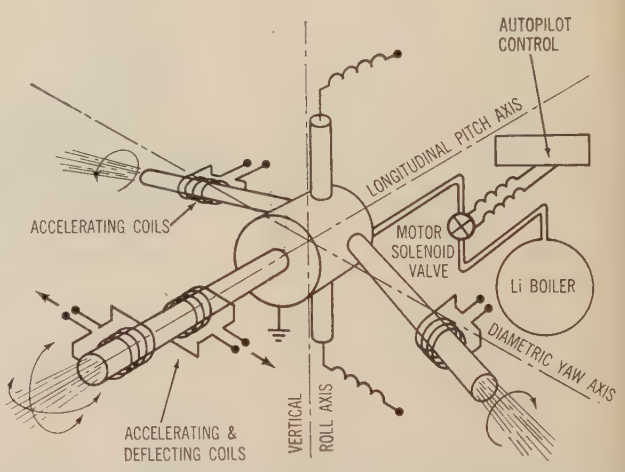
where n is the number of electrons per cubic centimeter (which often is about 10^{10}); e, the electron charge; m_e, the electron mass; and q_o, space charge.

Oscillations at 1000 mc typical

As we can see, the frequency of the electron oscillations depends on the electron concentration. A typical value is about 1000 mc (at 10^{10} electrons per cubic centimeter). Of course, ion oscillations may also occur. However, because of the much larger mass of the ions, the frequency in this case should be much smaller—perhaps one-thousandth of that of the electron oscillations.

A problem that often is side-stepped in discussions of plasma propulsion is that of the electric power supply. The relationship between power supply characteristics and plasma generator efficiency is by no means fully known. Researchers have found out, though, that the specific impulse rises with the average electric power level.

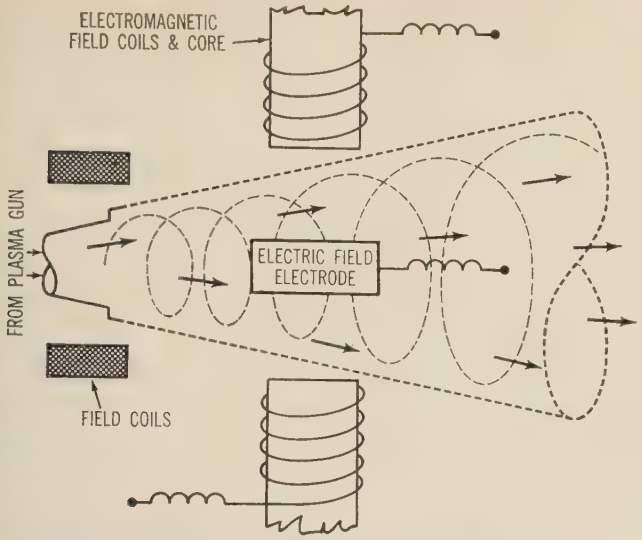
The trouble is that, at the present state of the art, the weight of an electric power supply increases with

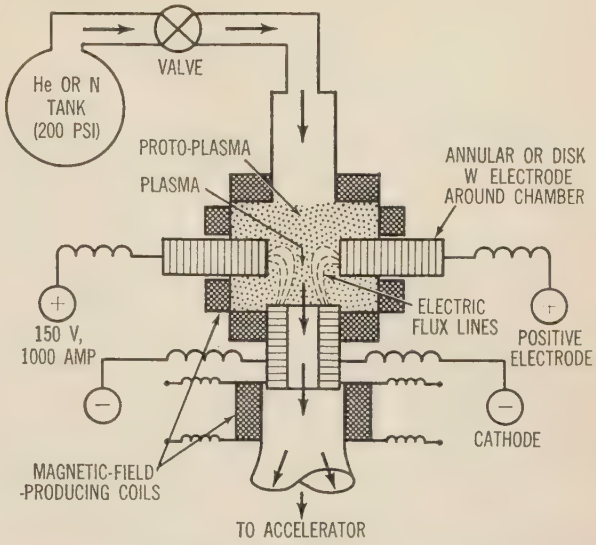


PLASMA GENERATOR and accelerating ducts could be used for spacecraft attitude control. The coils and gas flow throttling controls of the system can work in unison to provide attitude stabilization and control the rate of change of attitude control. The magnetic accelerating and deflecting coils can alter the velocity vector in at least the pitch-yaw plane and can provide throttling trim. The autopilot control is used for pitch, yaw, and toll stabilization and velocity trim. A motor valve acts as the throttle control.

the power level. In any plasma-propelled space vehicle of the near future, the mechanically rotating electric machinery used for power generation would be heavy enough to detract seriously from the vehicles performance. The designer actually would conclude pretty soon that, because of the power supply problem, plasma propulsion in this case offers no advantages over chemical propulsion.

Before plasma propulsion can become practical, therefore, lightweight nuclear power supplies—like those of the Snap program—must be developed. Fortunately,





SHAPED magnetic and electrostatic containing fields for plasma acceleration (left) produced by magnets and electric "dynodes" and normal to the plasma flow. Right: Simplified plasma "gun." In experiments, the walls might be water-cooled; on space missions, ceramic lining and "regenerative" gas cooling may be used.

work is well advanced in this country on lightweight radioisotope and nuclear-reactor units that can produce the several thousands of kilowatts needed for a plasma unit putting out a few pounds of thrust.

The power supply is not the only item whose weight poses problems. To produce the magnetic fields for accelerating the plasma, powerful electromagnets are needed that may weigh as much as all the rest of the engine. Permanent magnets have been proposed as substitutes for magnetic fields, but it has not been clearly shown how these can save weight, and there are also problems of magnetic field strength.

Even with a magnetic force field as the only practical means for accelerating a plasma, however, the picture is not entirely gloomy. In magnet design, some important breakthroughs have led to highly permeable alloys and new coil windings and shaped fields that will reduce the weight and bulk of electromagnets.

Heat transfer problems are tough

Heat transfer is another important problem in plasma propulsion. The electric arc itself generates heat prolifically, and heat will leak back through the electrodes and the containing wall. As we have noted, magnetic fields for containing the plasma help in this respect. However, they cannot stop radiative heat transfer to

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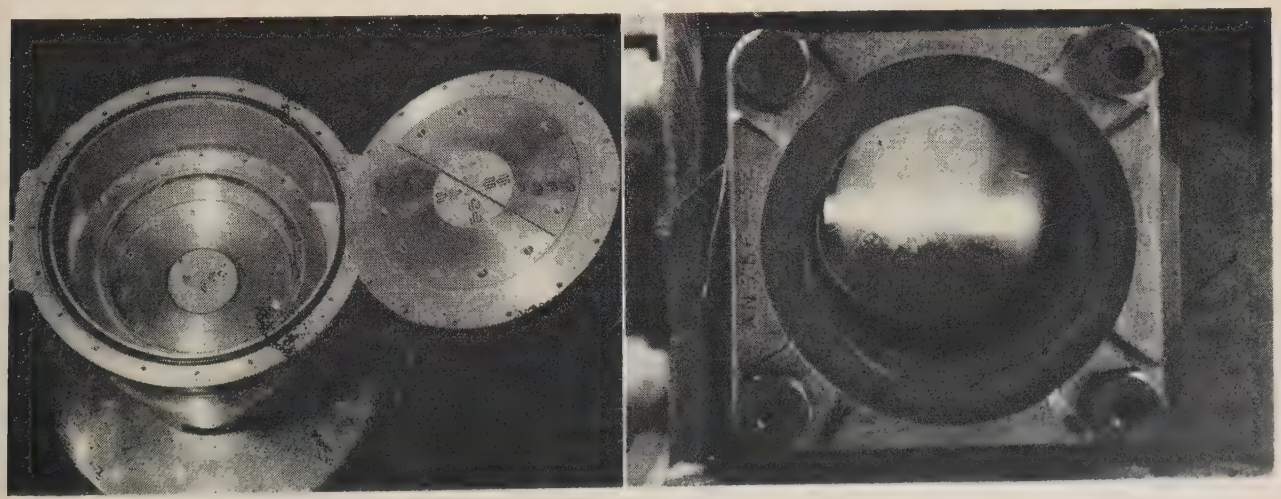
TOP AND BOTTOM electrodes of the plasma chamber at Republic (left). Photos of the pinch effect are taken through the slit in the top electrode. Right: GE electrothermal arc engine in operation.



the walls. To overcome this heat transfer, highly heat-resistant ceramic walls can be used. Heat transfer problems in the acceleration region should be relatively easy to solve—with properly shaped magnetic fields, very little convective or conductive heat transfer occurs at the boundary wall.

The design of the plasma "gun", or arc chamber, itself will require extensive studies of new materials, especially of such metals with high melting points as tungsten and molybdenum and their carbides. Actually, the straight electric arc is not the only device that will produce a plasma. The designer could also apply a technique similar to that used in the induction furnace: A small amount of working fluid is infused into the plasma chamber, where powerful magnetic fields set up by induction coils ionize and heat it. With proper sequencing and phasing of their currents, the coils can pinch the resulting plasma and accelerate it through a tube. The plasma also does some "self-pinching", because of its induced internal fields, which counter the external magnetic fields.

Looks very simple at first glance

This kind of plasma generator at first glance looks much simpler than the arc generator. Its drawback is that it provides only plasmas of low densities. At this point, we cannot predict whether the arc generator or the induction device will prove more practical in the end; all we can say is that most of our present efforts on plasma propulsion are centered around the arc generator.

Most U.S. researchers working on plasma propulsion at one time or another have also mentioned the plasma "fusion" rocket, which would be based on future results of Project Sherwood. A fusion rocket could yield specific impulses several orders of magnitude beyond anything we can expect to get from arc-generated plasmas. However, such a rocket so far is strictly a paper concept. After all, we haven't yet managed to harness nuclear fusion for such prosaic purposes as the generation of electric power.

How to get a large mass flow of plasma is another question that is still unresolved. Acceleration problems, nozzle losses, heat transfer, and arc power requirements all are reduced with a low plasma mass flow, or pressure. However, a low mass flow gives only a very low thrust, even with the plasma accelerated to high velocities. In any case, high exhaust velocities are not acceptable, because of the powerful magnets or electromagnetic fields they require.

Several plasma devices in cluster

One way out of this dilemma would be to cluster several plasma devices. This gets us into the problems of the interaction of the various plasma exhausts once they have left their nozzles and of phasing the various arcs to prevent pulsation and unstable operation. Nevertheless, some scheme of this sort must be devised if we are to get thrusts of more than a pound or two—that is, in the range over which plasma propulsion is most advantageous.

Plasma propulsion will give thrusts from about ten pounds to less than a few hundred pounds. For electric propulsion, these are relatively high figures. Together with a high specific impulse, and a basically simple design, they qualify the plasma engine for deep-space missions. It seems more than likely that plasma propulsion will be used within the next decade, if not within a few years, for spacecraft and payload stabilization and perhaps also for course corrections in the regions beyond the moon.—End

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REPUBLIC'S plasma pinch engine is inspected (l. to r.) by ARDC commander Maj. Gen. Bernard A. Schriever, Al Kunen, manager of Republic's Plasma Propulsion Group, and Republic president Mundy I. Peale, and observed in operation by a test engineer (right). The engine has chalked up a record of 118 hours of continuous operation.

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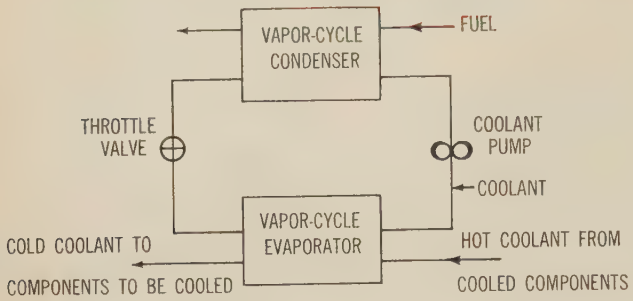

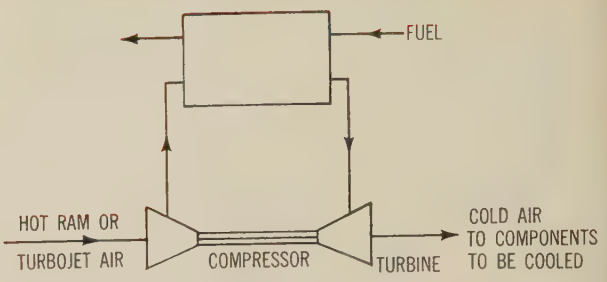

FIGURE 1: Basic cooling system arrangements.

How to use fuel as a heat sink

The higher flight speeds go, the harder it becomes to make good use of ram air for cooling. Cooling by expendable fluid isn't the answer either—it takes too much weight and space. By far the best idea, this article shows, is to use fuel as a heat sink.

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Project Propulsion Engineer & Propulsion Engineer, resp., Convair-Ft. Worth Div., General Dynamics Corp.*

FUEL IS the ideal heat sink to meet the cooling needs of future aircraft and missiles—being required anyway, it does not add to the vehicle weight, and it is available in quantity and at reasonable temperature. These characteristics clearly overcome the drawbacks of the conventional heat sinks of ram air and expendable fluid. The only limitations on fuel as a heat sink are imposed by inlet temperature, thermal stability (i.e., the allowable maximum temperature), vapor pressure variation with temperature, and the problems of fuel flow and management.

We will study here four basic types of fuel heat sinks: condenser, non-vaporizing, fuel-direct, and fuel boiler (*Fig. 2*). The actual fuels we'll consider in detail are JP-4 and -6 and RJ-1 (*Table II & Fig. 3*). Naturally, all other present or projected fuels (like the high-density and high-energy types and the rocket fuels) can also be used as heat sinks; the problem with them for our purposes here is that we know less about their physical properties.

The basic cooling-system components we'll consider are (*Fig. 1*):

- the final heat sink, or the heat sink for the entire system, which may use fuel, ram air, an expendable fluid (like water or ammonia), or any combination of these;
- the intermediate heat transfer fluid, which carries heat from the basic heat transfer fluid to the final heat sink;
- the basic heat transfer fluid, which receives heat from the vehicle equipment and carries it to the intermediate heat transfer fluid or directly to the final heat sink.

For our study, we will assume that the final heat sink is fuel, the intermediate heat transfer fluid is water, and the basic heat-transfer fluid is either air or a coolant (e.g., freon).

The *condenser* fuel cooling system consists of a water-boiler-type heat exchanger in which the basic heat transfer fluid transfers its heat content to boiling

* Convair-Ft. Worth Div., General Dynamics Corp., Grant's Lane, Ft. Worth 1, Texas.

Table I: Critical Cooling System Parameters

Final Heat Sink

- Fuel flow
- Fuel inlet temperature
- Maximum allowable fuel temperature
- Fuel system pressure drop

Basic Heat Transfer Fluid

- Type (air or refrigerant)
- Required mass flow
- Required heat rejection rates
- Inlet and outlet temperatures
- Allowable pressure drop

Intermediate Heat Transfer Fliud (Water)

- Temperature vs vapor pressure
- Required volume of make-up water to maintain boiling-condensing operation
- Additives to prevent freezing and corrosion, if required

water, the intermediate heat-transfer fluid, and a condenser, or steam-to-fuel heat exchanger, that condenses most of the water vapor and returns it to an integral water tank, or reservoir. This reservoir completely encloses the water boiler and the condenser. In addition there are a back pressure valve to control the water boiling temperature, a water separator or a superheater, and an anti-spill control.

Water-boiler performance is best shown by:

(1) $\epsilon_{wb} = (T_{air\text{-}in} - T_{air\text{-}out})/(T_{air\text{-}in} - T_{water\text{-}boiling})$,

where ϵ_{wb} is effectiveness of the water boiler and T is temperature (in degrees R). *Figure 4* plots ϵ_{wb} against the mass flow rate of the basic heat transfer fluid.

The design of the condenser is based on film-type condensation on banks of horizontal tubes and/or plates. Its details depend on the available space, the temperature limitations of the fuel and the basic heat-transfer fluid, and the water available for boil-off.

Finding heat transfer coefficients

The heat transfer coefficient of the steam, or condensate, side (h_s) ranges from 500 to 1800 btu/hr-sq ft-deg F, the precise value depending on the surface geometry, the temperature gradient between the steam and the condensing wall (Δt_c), and the steam velocity. Practical values can be estimated from:

(2) $$h_{sv} = 4800/[L^{1/4}(\Delta t_c)^{1/3}],$$

(3) $$h_{sh} = 5800/(ND)^{1/4}(\Delta t_c)^{1/3},$$

where L is length of the vertical tubes or plates (in feet); N, number of rows (counted vertically) of horizontal tubes; D, diameter of the tubes (in inches); and subscripts v and h denote vertically and horizontally condensing surfaces, respectively.

The heat transfer coefficient for the condenser's fuel

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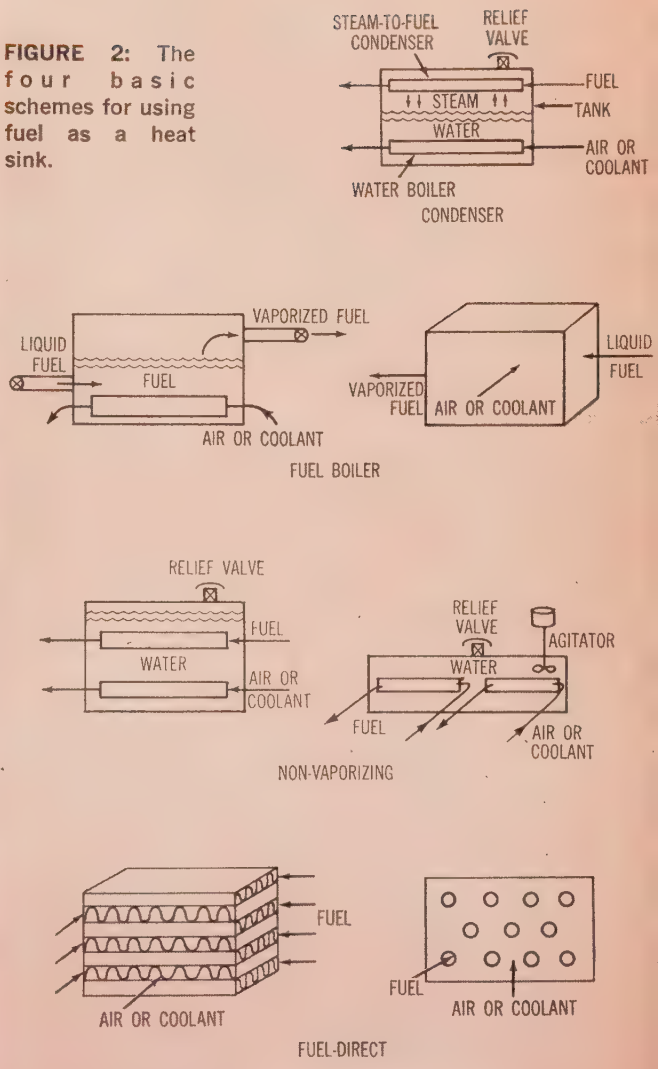
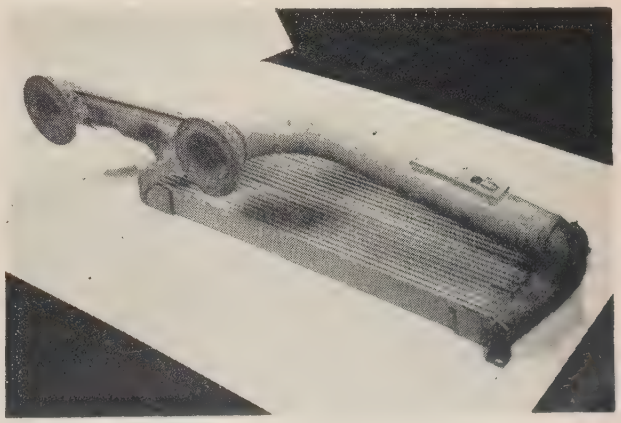
FIGURE 2: The four basic schemes for using fuel as a heat sink.



WATER BOILER for use in cooling system whose final heat sink is fuel is installed in the Convair B-58 Hustler bomber.



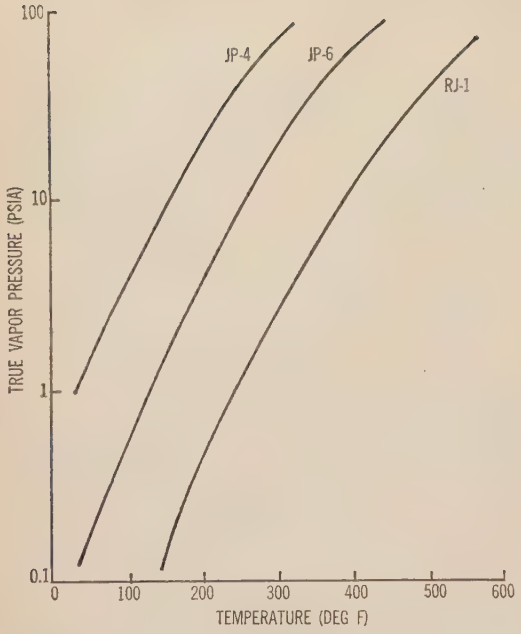


FIGURE 3: True vapor pressure of fuels considered in this study.

Fuel Properties

	Liquid Specific Heat (btu/lb-deg F)*		Thermal Conductivity* (btu/hr-sq ft-deg F)		Viscosity (lb/hr-ft)		
	100 deg F	400 deg F	100 deg F	400 deg F	100 deg F	300 deg F	400 deg F
JP-4	0.52	0.67	0.080	0.07	1.74	0.98	—
JP-6	0.52	0.66	0.08	0.07	2.	1.2	0.9
RJ-1	0.456	0.602	0.079	0.071	4.06	1.74	0.72

*Straight-line interpolation between these temperatures.

Typical Distillation (at 6.5 psia)

Temperature (deg F)	Boil-Off (per cent)
100	0
175	10
280	30
300	50
340	80
390	100

Latent Heat of Vaporization

Temperature (deg F)	Heat of Vaporization (btu/lb)
100	150
200	140
300	126
400	110

side (h_f) varies from 300 to 1500 btu/hr-sq ft-deg F. Practical values can be calculated from:

(4) $$h_f = (0.397 \times W_f \times 0.8)/(D \times 0.2),$$

where W_f is the fuel flow rate (in ppm).

The effectiveness of the condenser can be defined as:

(5) $$\epsilon_c = (T_{fuel\text{-}out} - T_{fuel\text{-}in})/(T_{steam} - T_{fuel\text{-}in}) = 1 - e^{-NTU}.$$

(6) $$NTU = U_c A_f / W_f C_{pf},$$

(7) $$U_c A_f = 1/(1/\eta_f h_f A_f + 1/\eta_c h_c A_c).$$

where U_c is overall condenser heat transfer coefficient (in btu/hr-sq ft-deg F); A_f, fuel-side area of the condenser (in square feet); C_{pf}, specific heat of fuel (in btu/lb-deg F); η_f, efficiency of the condenser's fuel side, assumed to be 1; η_c, efficiency of the condenser's steam side, assumed to be 0.9; and A_c, steam-side area of condenser (in square feet).

ΔT_{fuel} depends on condensation

For airborne applications, $U_c A_c$ ranges from 5000 to 20,000. *Figure 5* shows expected maxima for ϵ_c vs fuel flow that apply for most condensers suitable for future aircraft and missiles. Actually, ΔT_{fuel} depends on the required amount of condensation, so that:

(8) $$\epsilon_c = W_{water\text{-}boiled}/W_f C_{pf} \times (T_{fuel\text{-}out} - T_{fuel\text{-}in})/(T_{steam} - T_{fuel\text{-}in}),$$

where W_f/C_{pf} is greater than $W_{water\text{-}boiled}$.

The operating temperature of the overall boiling-condensing system depends primarily on the water boiling temperature as set up by the water-tank pressure. The water tank, or reservoir, may be vented to ambient pressure, have pressure-regulating valving, or be a sealed type.

Which of these pressurization methods is used depends on the inlet and outlet temperatures of the fuel and the basic heat-transfer fluid. With venting to ambient pressure, you have little or no control over condensation. Furthermore, the boiling-condensing operation becomes ineffective with the fuel inlet temperature close to the boiling temperature. With a sealed tank, on the other hand, weight penalties may be caused by excessive pressure build-up and you have no control over condensing and boiling temperatures.

Vent valve control works well

If the water boiling temperature is regulated with a vent valve, system performance can be controlled closely. The most effective use can be made of the fuel as a heat sink, so that only a minimum of water is needed as intermediate heat transfer fluid. For our study, we'll therefore assume that the system uses valving for pressure regulation.

Almost no controls are needed for the condenser system, mainly because the basic heat transfer fluid and the final heat sink never come in contact. The fuel flows continuously under all flight conditions and needs no modulation. Higher flows, however, may be needed, than for the powerplant, and in that case a fuel bypass back to the fuel tank is necessary.

The *non-vaporizing* system differs from the condenser system in only one major aspect: instead of being vaporized and condensed, the intermediate heat transfer fluid is circulated as a liquid between the basic heat transfer fluid and the final heat sink.

No agitation with small gradient

The water used as the intermediate heat transfer fluid in this arrangement may or may not be agitated, depending on many factors—the effectiveness of the heat exchangers, the temperature gradients between them and the water, the shape of the water tank, the type of

tank venting, etc. Free-convection water currents will do the job when there is a small temperature gradient between the water and the hot air or coolant and a large gradient between the water and the fuel.

When these conditions are not met, forced convection —i.e., agitation—is needed. Large temperature gradients between the basic heat transfer fluid and the water create a vapor seal around the heat exchanger surfaces that sharply reduces the heat transfer rate. Agitation disperses the vapor and also boosts the flow of water over the heat-exchanger surfaces of the final heat sink.

The effectiveness of the two heat exchangers (with agitated water between them) essentially is the same as that shown in *Figures 4 & 5*. The heat transfer coefficient for the water side of both heat exchangers (h_w) ranges from 1000 to 2500 btu/hr-sq ft-deg F and is expressed as:

(9) $$h_w = 870(1 + 0.0067T_f)V^{0.6}/D^{0.4},$$

where V is the velocity of the water flow past the heat exchanger tubes (in fps). *Equations 1, 4, 5 & 7* also apply.

Heat energy directly transferred

In the *fuel-direct* system, the basic heat transfer fluid transfers its heat energy directly to the final heat sink. The configuration of the system is straightforward and follows normal heat exchanger design practice. Either of the heat exchanger geometries shown in *Figure 2* may be used. *Figure 6* shows the heat exchanger performance for a shell-and-tube-type unit, in which the basic heat transfer fluid passes over fuel flowing through tubes. The effectiveness of the heat exchanger is given by:

(10) $$\epsilon_F = (T_{air\text{-}in} - T_{air\text{-}out})/(T_{air\text{-}in} - T_{fuel\text{-}in}).$$

Generally an additional, expendable heat sink is needed to get the low basic heat transfer fluid temperatures required for most environmental control systems. Because the fuel may overheat, there must also be special controls providing a bypass for hot basic heat transfer fluid.

In the *fuel boiler* system, the fuel used as the final heat sink is heated and in the end boiled off. The evaporated fuel can be:

- vented overboard,
- condensed and returned to the fuel line of the main propulsion system,
- returned to the fuel tank by bubbling the vapor through the liquid in the tank,
- delivered to the main engine(s) as vapor via a separate line.

New fuel must constantly be added

Either of the heat exchanger designs shown in *Figure 2* may be used. We'll assume that the air or coolant flows through tubes immersed in a tank of fuel. In this case, the effectiveness of the "fuel boiler" is essentially the same as that of the water boiler we have discussed (*Fig. 4*).

As fuel begins to boil, its lighter components are driven off, and the boiling point of the remaining fuel rises. To maintain a reasonably constant boiling temperature, new fuel therefore must constantly be added to the boiler. The boiling temperature will stabilize at some point between its minimum and its maximum.

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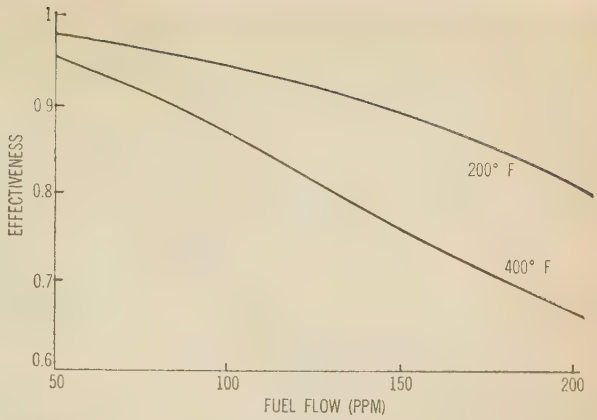


FIGURE 5: Effectiveness of the steam-to-fuel condenser for two mean fuel temperatures.

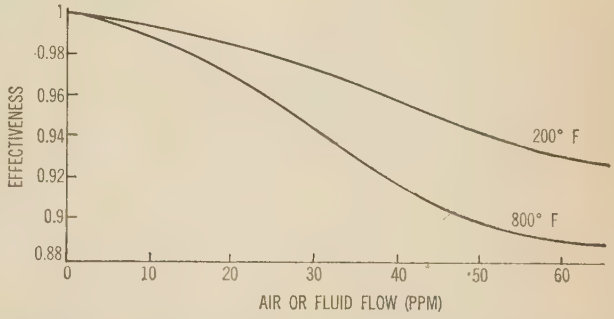


FIGURE 4: Effectiveness of water boiler for two mean temperatures of the basic heat transfer fluid.

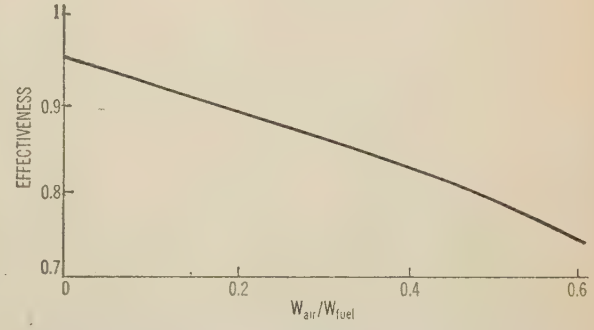


FIGURE 6: Effectiveness of the heat exchanger of a fuel-direct cooling system.

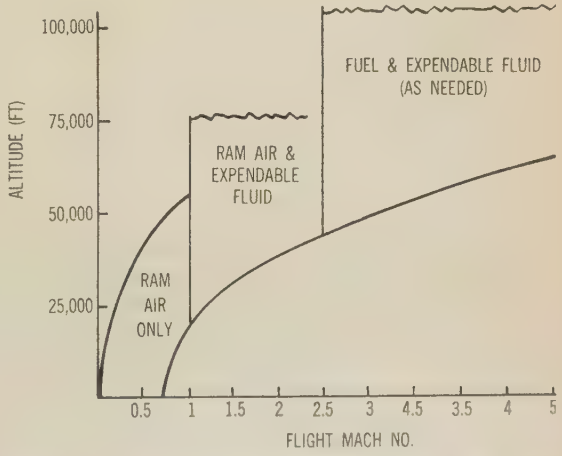


FIGURE 7: Operational envelopes for final heat sinks. The combination of ram air and expendable fluid is limited in duration.

Table III: System Comparison[1]

	Condenser		Non-Vaporizing		Fuel-Direct		Fuel Boiler	
	Single Unit	With Secondary Water Boiler[2]	Single Unit	With Secondary Water Boiler[2]	Single Unit	With Secondary Water Boiler[2]	Single Unit	With Secondary Water Boiler[2]
Water tank pressure (psia)	3	3	5	5	—	—	—	—
Water tank boiling temperature (deg F)	141	141	163	163	—	—	—	—
Fuel vapor pressure (psia)	—	—	—	—	—	—	5	5
Fuel boiling temperature (deg F)	—	—	—	—	—	—	200	200
Secondary water boiler temperature (deg F)	—	144	—	129	—	—	—	129
Overall effectiveness	0.985	0.985	0.985	0.985	0.92	0.92	0.985	0.985
Air outlet temperature (deg F)	145	130	166	130	120	120	202	130
Fuel outlet temperature (deg F)	110	110	109	109	111	111	108	108
Heat removed from air (btu/min)	985	1055	884	1055	1105	1105	710	1055
Heat absorbed by fuel (btu/min)	985	985	884	884	1105	1105	710	710
Heat to boil liquid off (btu/min)	0	70 (water)	0	171 (water)	0	0	0	345 (fuel)
Liquid boiled off (ppm)	0	0.07 (water)	0	0.171 (water)	0	0	0	3 (fuel)
Performance	good		fair		poor		poor	
Safety	good		good		poor		poor	
Installability	good		fair		poor		poor	
Reliability	good		fair		poor		poor	
Weight increase (range penalty)	small		small		large		large	

(1) Numerical values are based on Mach 4 vehicle speed, 80,000 ft flight altitude, JR-6 fuel, 200 ppm fuel flow, 100 deg F fuel inlet temperature, and 20 ppm of air as basic heat transfer fluid at 350 deg F inlet temperature.
(2) In series with first.

As there must be a constant flow into and out of the boiler, the heat absorbed by the fuel is taken up by sensible heating of the liquid and the latent heat of vaporization. When the fuel is cold, little, if any, boiling takes place; as the temperature of the inlet fuel goes up, so does the boiling rate.

What when the fuel gets too hot?

Table I lists the properties of a system (using fuel as the final heat sink and cooling an entire environmental control system) that determine the system's operational envelope (in terms of Mach number vs altitude). *Figure 7* shows such an envelope for the case of a long-duration mission.

Table III compares the four methods of using fuel as a final heat sink. A fundamental distinction can be made on the basis of what must be done when fuel temperatures are too high to produce the necessary low air or coolant outlet temperature. In the condensing and the non-vaporizing systems, which use water in an integrated arrangement, water can be boiled off in this case. For the fuel-boiler and direct-fuel designs, on the other hand, a water boiler in series with the original fuel heat exchanger is needed.

As *Table III* shows, the condensing and the non-vaporizing system are comparable in performance and suitability, the fuel boiler falls far behind, and the direct-fuel design looks best. However, the direct-fuel type has several drawbacks that make its use problematical: fuel is brought into close contact with hot air or coolant, fuel vapors must be removed, and controls are needed to keep the fuel from overheating. (All these disadvantages also apply to the fuel boiler, which furthermore confronts you with a troublesome choice: you either lose fuel or you must add expendable heat sinks to make use of it.)

Condenser system comes out best

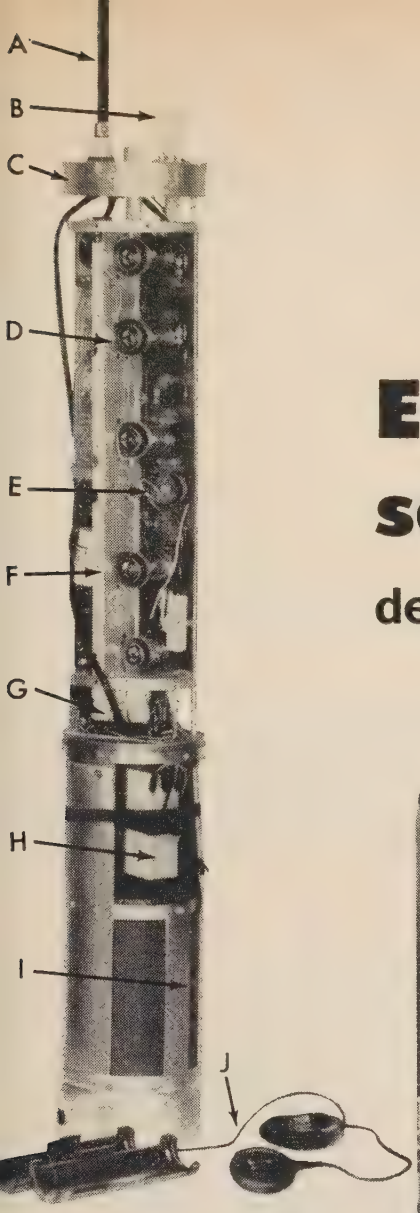
In a comparison of the condenser and the non-vaporizing systems, the latter shows a major drawback: high water tank pressures and/or fuel overheating may occur, and to prevent these effects you need additional controls. The combination of water boiler and steam-fuel condenser therefore offers the most practical method of using fuel as a final heat sink. It is safe, simple, controllable, and performs well.—End

Reference—W. H. McAdams, "Heat Transmission" (3rd ed.); McGraw-Hill ('54).

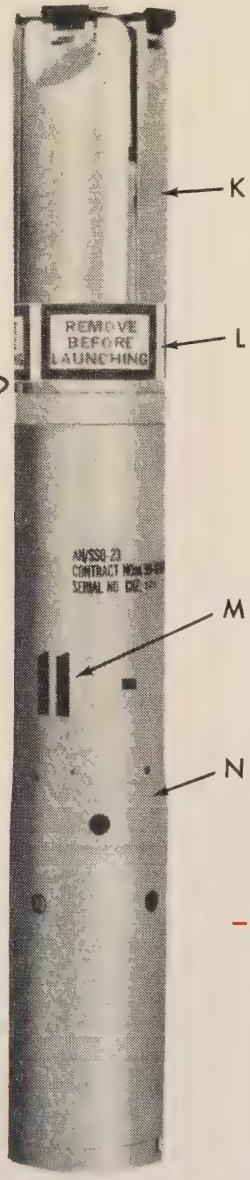
design progress

Expendable sonobuoy

designed for low cost production



COMPONENTS of AN/SSQ-23 sonobuoy: A—VHF antenna, B—S- and X-band antenna, C—antenna deck, D—VHF transmitter, E—beacon receiver, F—hydrophone amplifier, G—power supply, H—battery pack, I—release guide tube, J—hydrophone and cable.

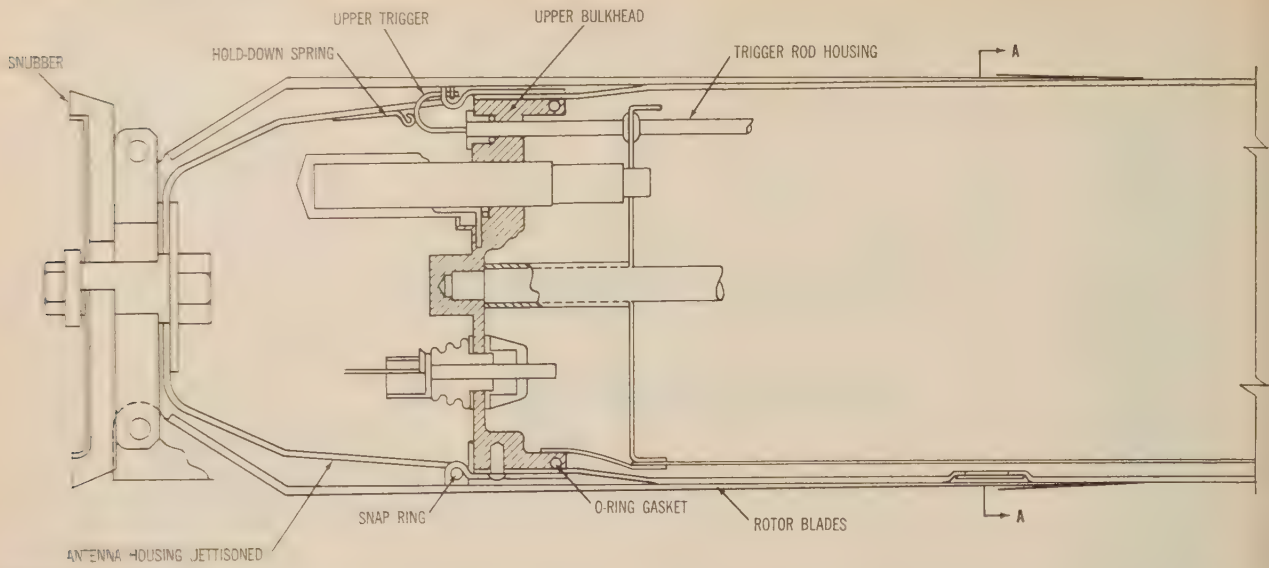


ASSEMBLED AN / SSQ - 23 sonobuoy: K — rotating blade head, L—pre-launch safety tape, M—frequency channel marking, N—main housing, O—trigger plate.

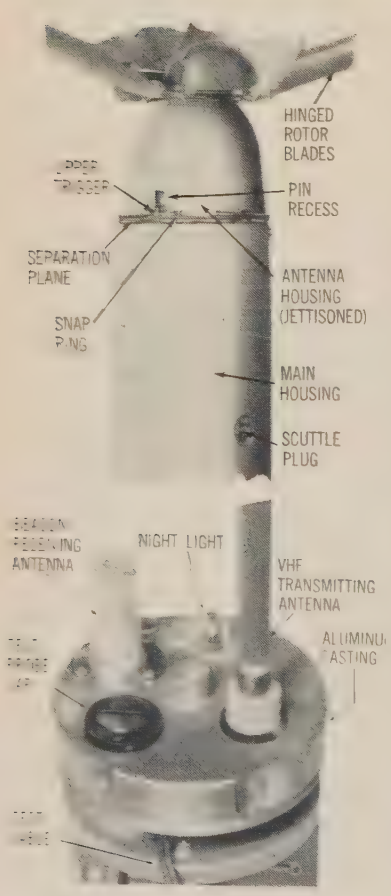
SEVERAL THOUSAND AN/SSQ-23 sonobuoys are being built for operational training and use. Fabrication and assembly costs were of paramount importance in the production design. Developed by the Hazeltine Corp., Little Neck, N. Y., the AN/SSQ-23 is 36⅛ in. long, 4⅞ in. in diameter, and weighs close to 18 lb. It can be launched from aircraft flying at speeds up to 250 knots at 500 ft altitude. An auto-rotating blade head slows down and strightens out the descent, so that the sonobuoy hits the water at a 90-deg attitude within 9-11 seconds of release. A trigger plate at the bottom of the housing absorbs the shock of the water impact (up to 200 Gs), triggers the rotating-head jettison, and then drops free of the housing and sinks into the water, followed by the unwinding cable and hydrophone. A scuttling plug after one hour allows the buoy slowly to fill with water. The buoy then sinks, and the transmission frequency is kept open for new data.

more on next page

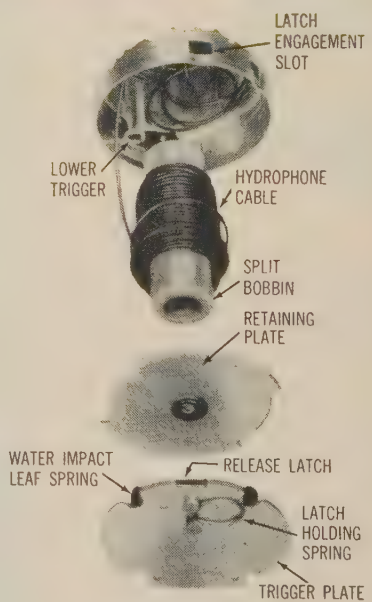
by Victor de Biasi,
Associate Editor



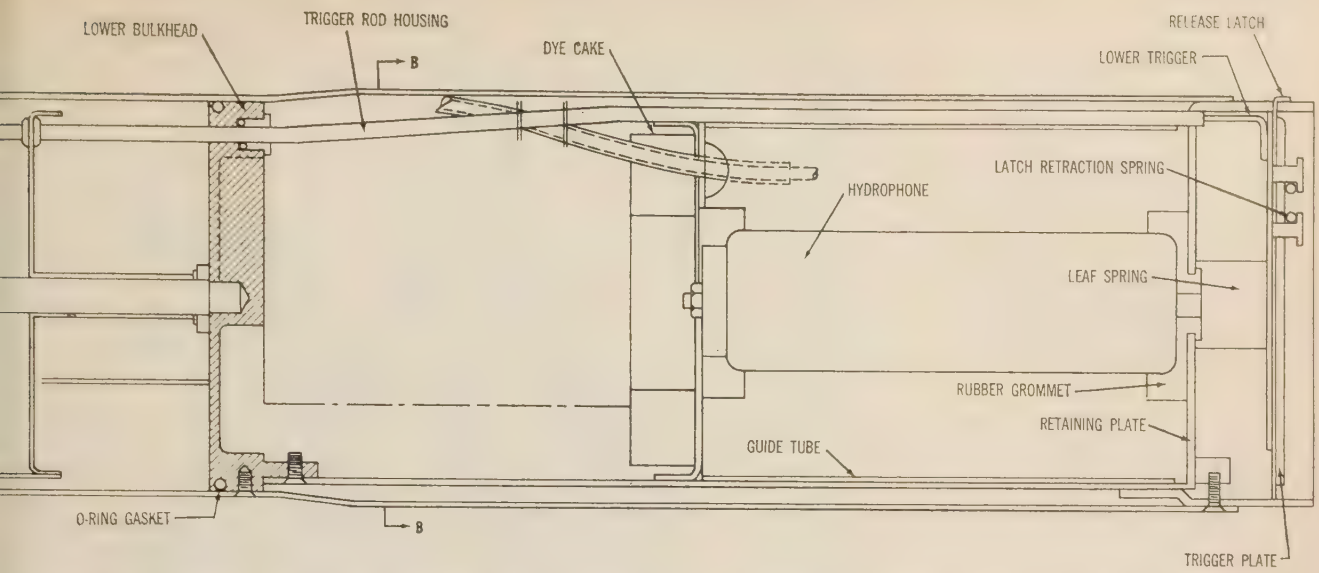
ROTATING HEAD and antenna housing are ejected when the upper trigger is pushed out of the retaining ring. The O-ring gasket around the upper bulkhead keeps water from seeping into the electronics section. Longitudinal stringers butt up against the circuit boards (Section A-A) to keep them from deflecting under rotational forces induced by the rotating blades. A rubber shock absorber and nylon tie around each cantilevered tube help reduce microphonics. Interacting spring design in the lower end of the housing absorbs the water impact and triggers sonobuoy operation. Upon installation, the trigger plate retraction spring is spread apart to extend the release



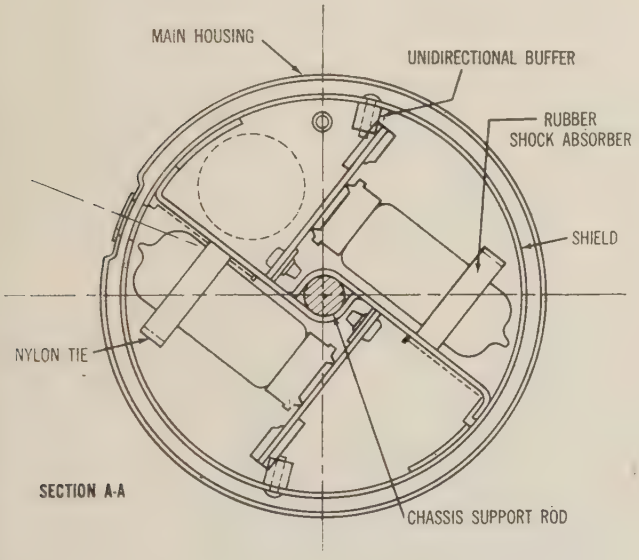
ROTATING-BLADE head (top) acts as a speed governor. Rubber snubbers take up the initial shock of the air impact (up to 100 g). Once rotating, the blades continuously droop or erect themselves, depending on the centrifugal force, to accelerate or decelerate the descent. A snap ring is triggered by the water impact (up to 200 g) to release the rotating head. Bottom: Beacon receiving antenna, protected by a polyethylene radome, consists of a stacked array of half-wave trislots (for X-band operation) and a single quarter-wave slot (for S-band).

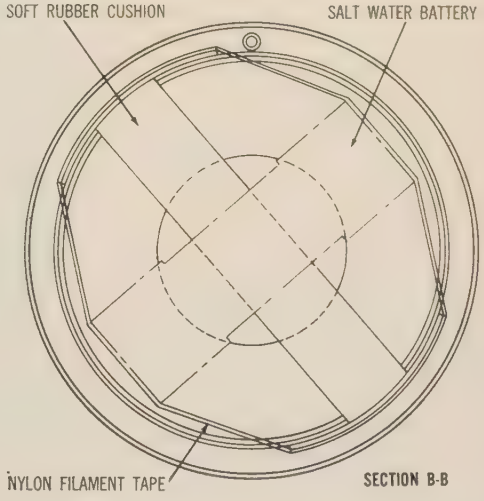


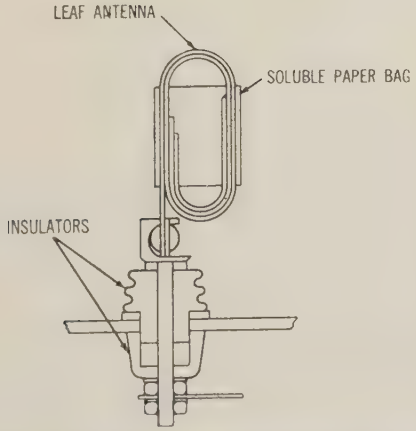
WATER IMPACT forces the trigger plate up against the retainer. This frees the release latch, which automatically snaps back into the disengage position. Once free, the trigger plate falls away from the housing, followed by the retaining plate, hydrophone (inside split bobbin), and unwinding cable. The lower trigger is also actuated upon impact to unhook the upper trigger and release the retaining ring that locks the rotating head to the main housing.



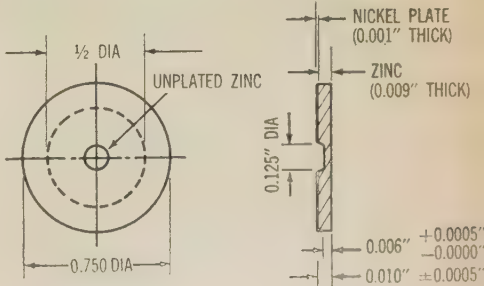
latch and engage a slot in the outside housing. Releasing the spring locks the latch in place. The water impact compresses the leaf spring and moves the trigger plate into the housing. The latch now can clear the slot and spring back into the disengage position. The trigger plate action also actuates the lower trigger. The sea-activated battery is seated in a rubber cushion mounting (Section B-B). It is also tightly wrapped with nylon filament tape. The steel leaf VHF antenna is rolled up and housed inside a filter paper bag upon installation (bottom). Once it gets wet, the paper dissolves and allows the antenna to spring up and erect itself.







GALVANIC scuttling plug was specially developed as an improvement over water erosion designs. Gold and zinc generate the greatest possible potential. Slot is sized to allow about one hour for the galvanic action to eat through the disk.



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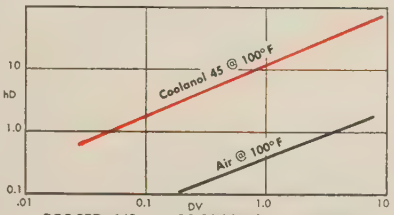
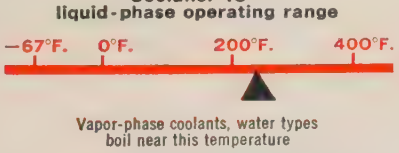


FORCED AIR vs. COOLANOL 45 COOLING
h = Film Coefficient (BTU/hr/°F/ft²)
D = Diameter of Channel (ft)
V = Velocity (ft/sec)

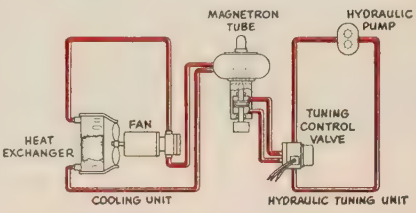
efficient liquid cooling is than forced air. Liquid cooling requires less heat-transfer area for the same heat load; volume flow rates as much as 25 times lower; smaller cooling channels and no bulky fins, fans or blowers.

2. Liquid-phase... even at 400°F. The high boiling point of Coolanol 45 allows its use in operating systems to 400°F. Fluid flow past hot-spot areas can be precisely controlled with Coolanol 45... without boiling which can cause pump cavitation and vapor binding. Water-glycol types or the vapor-phase coolants cease to function as pumpable liquids near the 200°F. mark. You don't need extra pressurization equipment or special pressurized lines for liquid-phase Coolanol 45.



3. One fluid for cooling and hydraulic needs. Coolanol 45 has good lubricity and makes an excellent high-temperature hydraulic fluid. It permits you to standardize on *one* fluid for both cooling and hydraulic needs—simplifies complex systems, and reduces variables.

The schematic depicts a countermeasure unit in which Coolanol 45 cools the magnetron tube and actuates the hydraulic tuning mechanism.



4. Standard materials and compatible equipment available now. Packings and seals are available in many compoundings and configurations for temperatures normally found in Coolanol 45 systems. The most widely used materials are Neoprene W, LS-53, and Buna N. Also, backup rings and hose assemblies are readily available for high-temperature use. Several manufacturers supply off-the-shelf cooling packages for Coolanol 45 systems; others will build complete cooling packages to specification. For information on complete cooling systems or component suppliers, write Monsanto.

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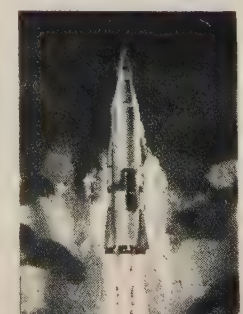


CONVAIR DIVISION OF GENERAL DYNAMIC

Simpler wing location

for a specified longitudinal stability

With complexity rampant in today's aerospace industry, every short cut is more than welcome to the designer. Here's a simplified approach for locating the longitudinal position of a wing for a specified longitudinal stability.

by Karl L. Sanders, Senior Research Engineer, Preliminary Design, Advanced Design Engineering Div., Ryan Aeronautical Co.*

N THE preliminary design of aircraft and winged missiles, the wing must be positioned for a desired longitudinal stability once the configuration of the fuselage and horizontal tail surface is known. Normally this is an iterative process implied by the interrelationship between CG position and the length of the horizontal tail during shifting of the wing. Iteration can be almost completely eliminated, if you use the derived analytical expression presented here. The only exception is the variation of the $AC_{tail-off}$ with X_{LEMAC} (i. e., forebody length). However, the value for the $AC_{tail-off}$ that we will use in our equation can be closely approximated for the expected wing location.

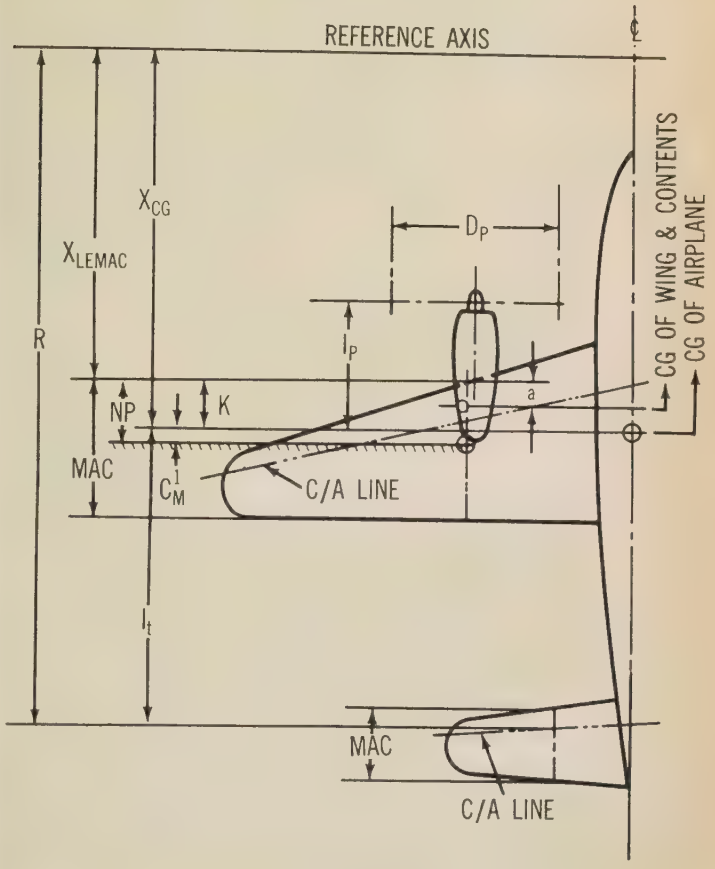
Our equation holds for both sub- and supersonic speeds, provided the proper values of the aerodynamic coefficients are used. It is especially useful in applications of the area rule. In deriving it, we will assume that wing planform, size, wing weight, and horizontal tail volume are known.

The basic relationship for the CG is:

(1) $X_{CG} = X_{LEMAC} + KMAC$

$= [M' + (X_{LEMAC} + aMAC)W_w]/\overline{W},$

where X_{LEMAC} and X_{CG} are the distances from the



PARAMETERS for wing location computation for a given longitudinal stability with almost none of the usual iteration. Only the variation of $AC_{tail-off}$ with X_{LEMAC} requires an iterative process; however, the value for $AC_{tail-off}$ can be closely approximated for this computation.

(1) Ryan Aeronautical Co., Lindbergh Field, San Diego 12, Calif.

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reference axis to the leading edge of MAC, respectively (in inches); K is aircraft CG location (as a fraction of MAC); MAC, mean aerodynamic chord; M', aircraft moment about the reference axis for the critical condition without the wing or any wing contents (in in.-lb); a, CG location of wing and contents (as a fraction of MAC); W_w, weight of wing and all-wing contents (in pounds), and $\overline{W}$, aircraft weight for the critical condition (in pounds). It follows that:

$$(2)\quad X_{LEMAC} = [M' + MAC(aW_w - K\overline{W})]/\overline{W} - W_w)$$

Specifying a static margin ($C_{m'} = dC_{mCG}/dC_L = NP - K$), we first consider the neutral-point (NP) equations for "power on" and "propellers windmilling", using whichever gives the lower value:

$$(3)\quad NP_{stick\text{-}fix} = AC_{tail\text{-}off} - 2ZC_L/\pi MACA_e - [(dC_N/d\alpha)_P(1 + d\epsilon/d\alpha)_w 0.25\pi {D_P}^2 \sum_o^N l_P]/C_{L\hat{\alpha}w}S_wMAC + (C_{L\hat{\alpha}t}S_t l_t q_t/C_{L\hat{\alpha}w}S_wMACq_w)(1 - K_S d\epsilon/d\alpha)$$

$$(4)\quad (NP_{stick\text{-}free} = NP_{stick\text{-}fix} - (C_{m\delta}/C_{L\hat{\alpha}w})(C_{h\alpha}/C_{h\delta})(1 - K_S d\epsilon/d\alpha)$$

where NP equals K for $C_{m'} =$ and is expressed as a fraction of MAC; $AC_{tail\text{-}off}$ is the aerodynamic center of the wing-body-nacelle configuration (as a fraction of MAC); and does not equal $NP_{tail\text{-}off}$;[2] Z, distance of thrust axis from CG; C_L, lift coefficient; A_e, effective wing aspect ratio; $(dC_N/d\alpha)_P$, propeller normal force coefficient slope (in reciprocals of radians);[3] $(1 + d\epsilon/d\alpha)_w$, upwash factor;[4] D_P, propeller diameter (in feet); N, number of propellers; l_P, distance of propeller disk plane from aircraft CG (in feet); $C_{L\hat{\alpha}}$, lift-curve slope (in reciprocals of radians); S, gross area (in square feet); l_t, distance from aircraft CG to 0.25 MAC of the horizontal tail (in inches); q, dynamic pressure (in psf); $1 - K_S(d\epsilon/d\alpha)$, downwash factor, including slipstream factor K_S, whose average values are 0.5 for turbojets and 0.4 for propeller aircraft with "power on";[5] $C_{m\delta} = dC_mCG/d\delta$, moment coefficient slope with respect to elevator deflection angle (in reciprocals

(2) Perkins, "Aircraft Performance Stability and Control"; NASA TM 1036.
(3) NASA WR L-217, Rep. 941.
(4) Perkins, *op. cit.*
(5) NASA WR L-25, Rep. 941.

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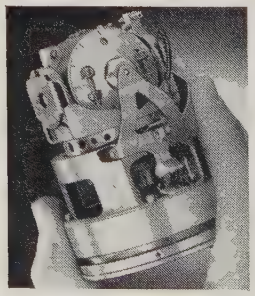

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of radians);[6] and C_h, hinge moment derivative (in reciprocals of radians), with the subscripts t, w, α, and δ referring to horizontal tail, wing, angle of attack, and elevator deflection, respectively.

Usually $NP_{stick\text{-}fix}$ exceeds $NP_{stick\text{-}free}$, so that the former is not important in our case. For *Equation 3* we may write:

5) $NP = A - B - C + Dl_t$,

where A, B, C, and D represent the terms of *Equation 3*, with D equaling $[(d\Delta C_m)_t/dC_{Lw}]_{CG}/C_t$ in.$^{-1}$. For propeller-driven aircraft, C approximately equals $-0.02N$; for pure jets, it equals zero.

The value for l_t can be closely approximated

As you can see from *Equation 3*, the tail volume ($\bar{V} = S_t l_t / S_w MAC$) must be found. Usually the most stringent requirements are imposed during the landing approach (by trimming out negative flap moments) and by raising the nose wheel off the ground at takeoff. Since the wing weight affects the total CG only slightly, l_t can be very closely approximated for the purpose of calculating $\bar{V}$.

The *Diagram* shows that:

(6) $l_t = R - X_{LEMAC} - (NP - C_m')\,MAC$,

(7) $K = NP - C_m'$,

where R is the distance from the reference axis to 0.25 MAC of the horizontal tail.

By equating *Expressions 5, 6 & 7* and substituting for K in *Equation 2*, we get a final expression for the location of the leading edge of MAC for a specified static margin:

(8) $X_{LEMAC} = [M'/\bar{W} + MAC\,((W_w/\bar{W})a - \{[A - B - C + D(R + C_m'MAC)]/(l + DMAC) - C_m'\})]/1 - W_w/\bar{W} + DMAC/(l + DMAC)$.

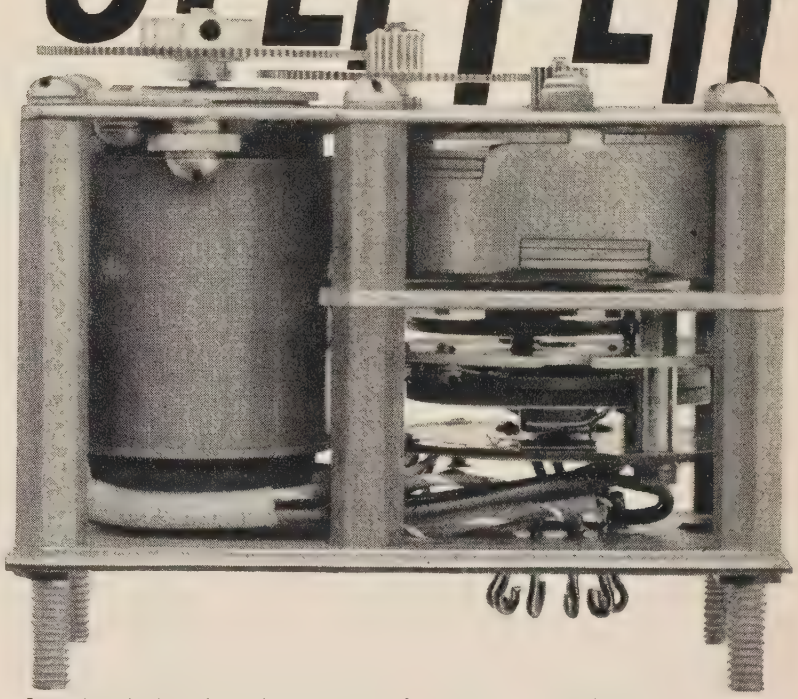
A critical condition for the wing location can be established by the aft-most CG position, which determines the minimum static margin. For acceptable handling qualities, the minimum value of this margin should equal at least 0.05 MAC.

Our equations apply for a CG location behind the $AC_{tail\text{-}off}$ and a thrust axis below the CG. If the thrust axis is beyond the CG, B in *Equations 5 & 8* changes sign. If the CG is in front of the $AC_{tail\text{-}off}$,

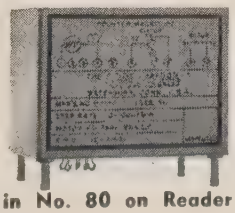
(6) Perkins, *op. cit.*, Figure 5-33 and Equation 5-72

more on next page

FANCY STEPPER



Stepping devices from A. W. Haydon Co. can do wonderful things to pulses ...with pulses...and for pulses. For instance, one precision gated stepping switch acts as a pulse divider for a random or variable pulse source—or as a frequency divider if the pulse source is constant. Another works in conjunction with pulses, supplying single or multiple switch closures with an accuracy virtually equal to that of the pulse source itself. Still a third will count a predetermined number of pulses, rotate a stepper switch, return the counter to 000, and cut off the pulse source. ■ The remote positioning device illustrated is but one of A. W. Haydon Company's fancy steppers. Here a precision gated stepper switch has been coupled to a synchro transformer. Similarly, precise angular positioning of rotary components such as potentiometers, dials and indicators can be controlled. Based only on the number of pulses received (not incremental changes in voltage or phase angle), it will hold a set position whether power is on or off, and will home the synchro to the zero reference on demand—ready to accept another setting. ■ All A. W. Haydon Co. stepper motors are all-electric—no ratchets, linkage, contacts or other mechanical crutches are used. Their power consumption is low, accuracy is extremely high. ■ Send for technical brochure SP9-1 and find out more about pulse driven steppers and their application.



THE AWH HAYDON COMPANY

223 North Elm Street, Waterbury 20, Connecticut

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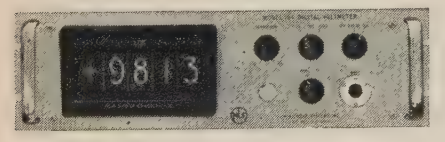
C and *D* also change sign in these equations. For jet-propelled vehicles,, the third term in *Equations 3 & 5* as well as *C* in *Equation 8* vanish.

When you use *Equation 8* for canard configurations, the last term (tail volume) in *Equations 3, 4 & 5* and the *D*-terms in *Equation 8* change sign. The canard surface moves the NP in front of the $AC_{tail-off}$ (while a tail surface shifts the NP behind $AC_{tail-off}$). The wing of a canard configuration must be placed farther aft than it would be with a normal tail if longitudinal stability is to be insured (i.e., the NP is to fall behind the CG for a negative, or stable, moment curve slope).

A special application of *Equation 8* occurs in finding the required leading edge sweep (for balance) and stability for aircraft modifications involving a fixed wing-root carry-through.—End

A Full Four-Digit Voltmeter at a Pointer Meter Price!



FOR THE FIRST TIME you can have the accuracy, speed and reliability of an NLS digital voltmeter with full four-digit resolution . . . for the price of a quality pointer meter. That's the dramatic story of the new NLS V64! Only NLS high-volume production techniques make it possible. Use low-cost, versatile V64 for a wide range of measuring jobs. See the V64 in action . . . contact NLS today!

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UP TO OUR EARS!

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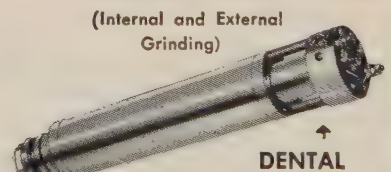
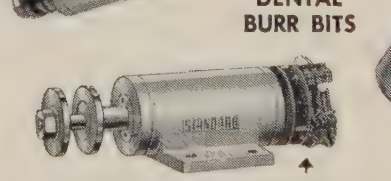
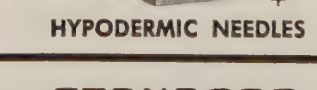
STANDARD SUPER PRECISION SPINDLES
ARE FINISHING DOZENS OF HARD METALS!



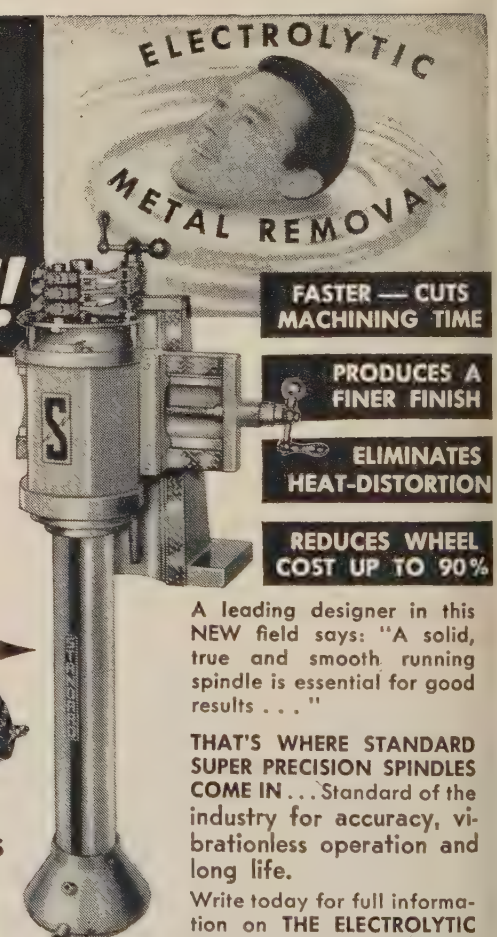
AIRCRAFT PARTS
(Internal and External Grinding)



DENTAL BURR BITS



HYPODERMIC NEEDLES



A leading designer in this NEW field says: "A solid, true and smooth running spindle is essential for good results . . . "

THAT'S WHERE STANDARD SUPER PRECISION SPINDLES COME IN . . . Standard of the industry for accuracy, vibrationless operation and long life.

Write today for full information on **THE ELECTROLYTIC GRINDING PROBLEMS WE'VE HELPED SOLVE** . . . we'll work with you on yours. 75 to 3000 Amperes.

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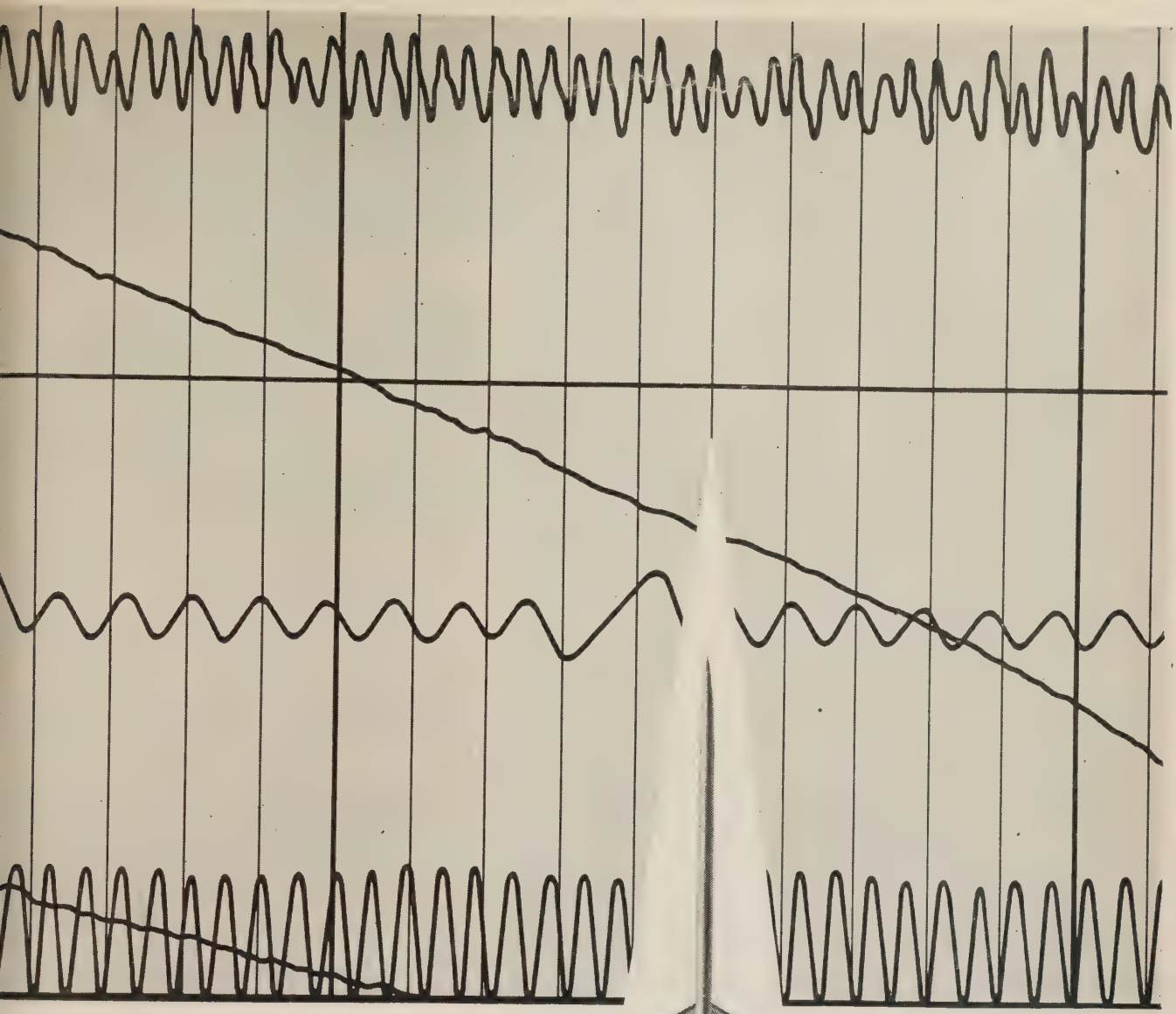

GET IT FAST, GET IT CLEAR ON LINO-WRIT 4

u Pont Lino-Writ 4 is the fastest, toughest, whitest photorecording aper you can use. It accommodates writing speeds as high as 5000 os at maximum amplitude; has exceptional exposing and processing titude; its ultra-thin, all-rag stock has unusual wet or dry strength.

ur other outstanding papers include:

no-Writ 1. Orthochromatic paper designed for test requirements lower writing speeds.

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no-Writ 3. For high-frequency oscillographic traces without loss detail.

These three papers are available in two types: Type B, standard-weight stock when greater opacity is required and Type W, a thin 100% all-rag stock.

Lino-Writ Rapid Processing Chemicals Kit is Du Pont's high-speed, low-odor formulation designed for rapid stabilization processing of all Du Pont photorecording papers.

For more information on our complete photorecording line, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, 2430-A Nemours, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

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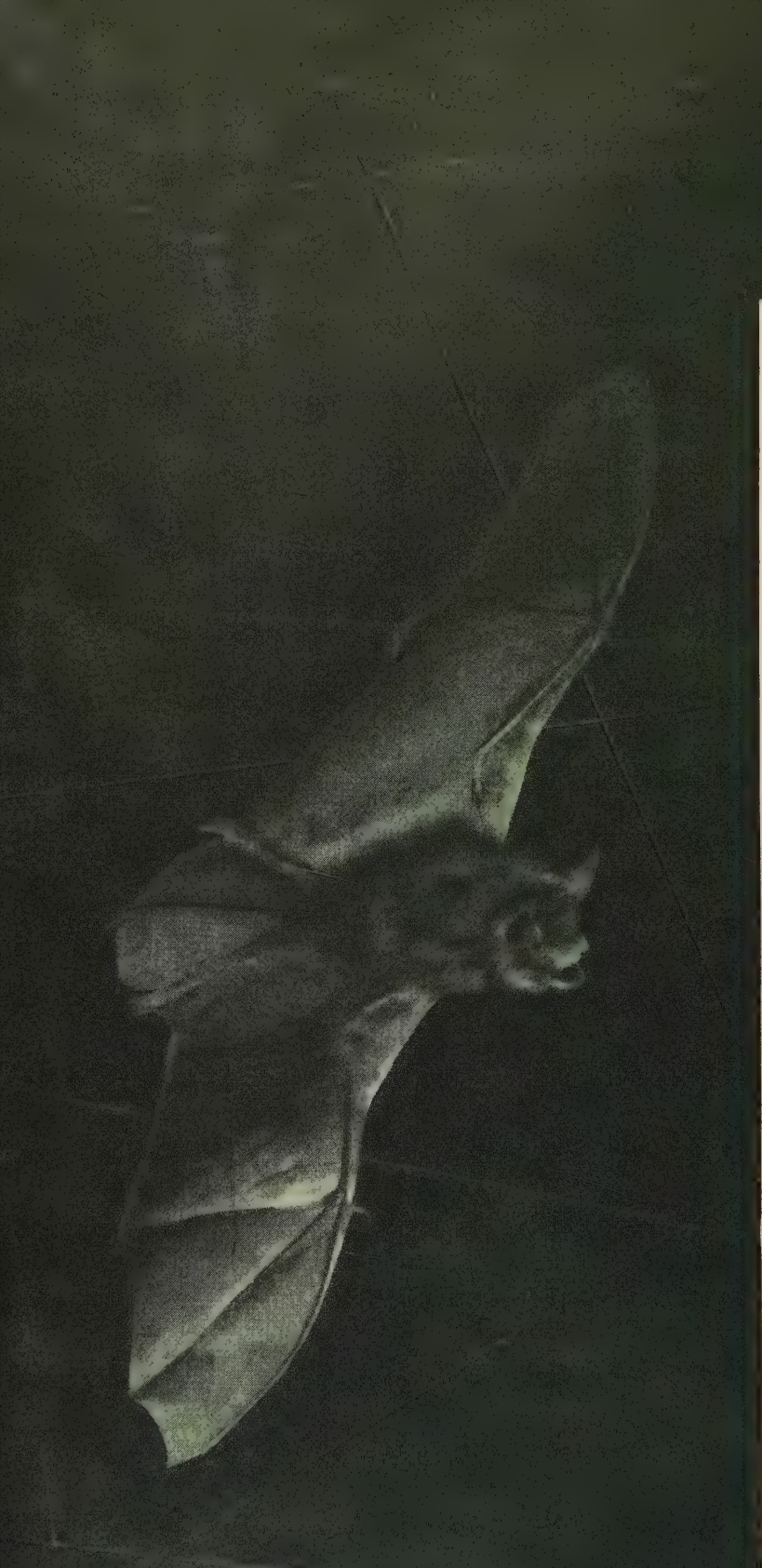

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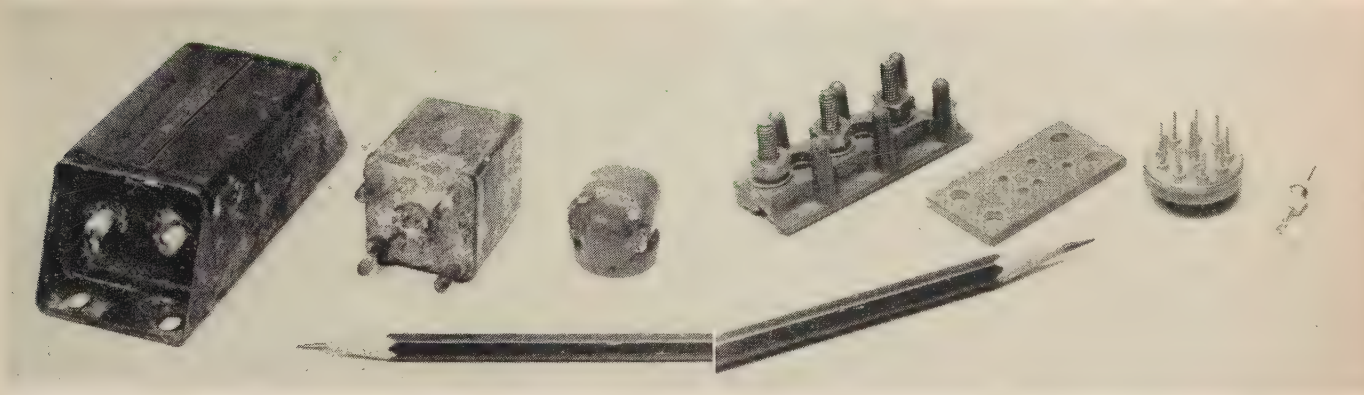
SYSTEMS, EQUIPMENT & COMPONENTS FOR

AIRBORNE NAVIGATION • RADAR and SURVEILLANCE • ELECTRONIC DATA PROCESSING • AUTOMATIC CONTROLS • GROUND SUPP



TERMINALS and terminal board (right) tested for high temperature service. Left: Thirty-four-VA filament transformer, 650-deg F signal transformer, and equivalent low temperature signal transformer.

Electric components

proved out for 600 deg F ambient

Do we have electric components for satisfactory operation in ambients from 600 to 650 deg F? Yes, says this report on an extensive environmental test program, in which parts were exposed to high temperature shock, acceleration, mechanical shock, noise, ozone, sand, dust, salt spray, and humidity.

by Kenneth A. Teumer, Group Engineer, Development Engineering, Sundstrand Aviation Div., Sundstrand Corp.*

IN THE advanced aircraft of the near future, electric components will have to withstand severe temperature conditions. Boundary layer skin temperatures are estimated at about 550 deg F at Mach 3. The typical compartment near the skin into which heat is dissipated by electric parts can be expected to have an ambient temperature of about 600 deg F.

A circuit with parts proven for 600 deg F operation will be at least 25 per cent heavier than one of equal electric rating whose parts are proven for 160 deg F. However, cooling equipment for lowering the ambient temperature to make it suitable for 160 deg F parts would be so heavy that there is a net saving in weight if 600-deg F parts are used.

Vibration requirements also affect the weight of a high temperature electric assembly. Available encapsulating compounds that can endure high heat and are strong enough to support parts subjected to a 20-g vibration are very dense. On the other hand, where vibration is low, no encapsulation may be needed.

Available vibration isolators do not have a satisfactory life at 600 deg F, because of the lack of springs and suitable damping devices. Existing elastomers don't have adequate life at 600 deg F. However, spring materials like

more on next page

* Sundstrand Aviation Div., Sundstrand Corp., 2421 11th St., Rockford, Ill. This is a condensation of a paper, "Electrical Components for a 600-deg F Control Circuit," given at the Air Transportation Conference held by the American Institute of Electrical Engineers at Seattle, Wash., last April.

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*PROGRESSIVE MANAGEMENT

*Another reason ROHR is a company known by the PEOPLE it keeps!

Progressive, "shirt-sleeve" management has guided Rohr to a pace-setting position in the aerospace industry—a position that means greater rewards to people who join the company.

Rohr's carefully charted course of diversification and growth has resulted in unusual stability and a record backlog of nearly a quarter billion dollars, well over half in commercial contracts.

Sound management is not a happenstance at Rohr. The company long ago embarked on a series of programs to develop and encourage management skills among its people. Newest technique is mobile training units, illustrated below . . . a method pioneered by Rohr.

Progressive management, product diversification, expanding facilities, distinguished associates, fine living conditions . . . these are among the many reasons that Rohr is *the company known by the people it keeps!*

Rohr invites inquiries from men who can contribute to the company's leadership in the aerospace industry. Write to Mr. J. L. Hobel, Industrial Relations Manager, Rohr Aircraft Corporation, P.O. Box 878-K, Chula Vista, California.

WORLD'S LARGEST PRODUCER OF COMPONENTS FOR FLIGHT

ROHR AIRCRAFT CORPORATION

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Check Employment Inquiry Form on Page 165

17-7PH stainless, Inconel X, and cobenium are definite possibilities. Bronze alloys are being studied for a damper that would use dissimilar metal contact damping. In general it appears that all-angle vibration isolators good for 600 deg F ambient could be developed reasonably quietly once there is a need.

An electric assembly for 600 deg F will be larger than an equivalent circuit rated for lower temperatures. The bigger parts, however, can be arranged in a dense package. Since many parts are rated at 400 and 500 deg C, hot spots due to component heat dissipation should cause little trouble.

As part of its development work on a constant-speed alternator drive control system, Sundstrand tested inductors, transformers, potting compounds, hookup wire, and terminals under the following conditions:

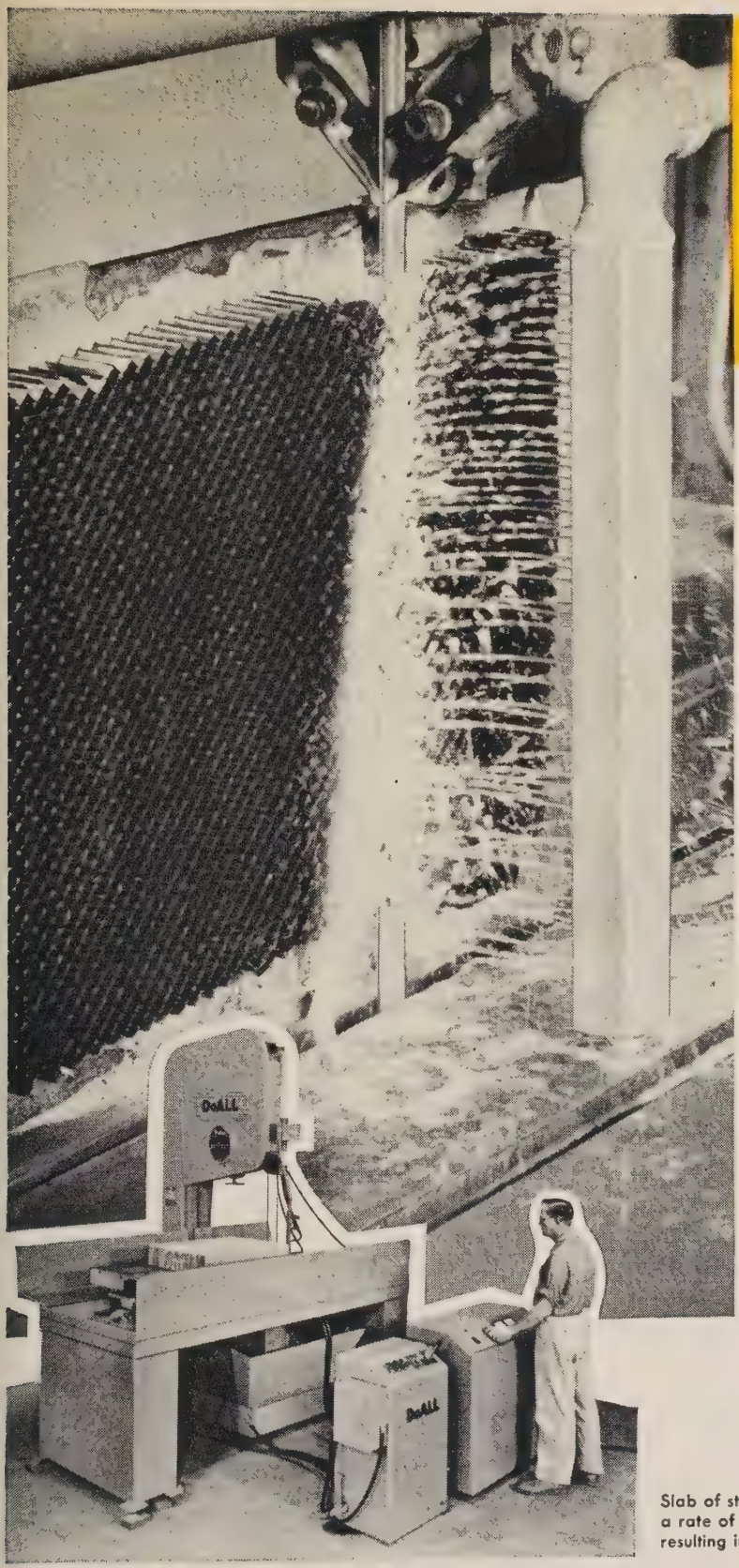
- 20 hours at 560 deg F and 80,000 ft, or 0.82 in. Hg;
- minimum temperature shock of 150 deg F/min up to 600 deg F;
- 20 g acceleration up to 2000 cps at 650 deg F ambient for two hours in each of three mutually perpendicular planes;
- 50 g mechanical shock for 11 millisec;
- 145 db acoustic noise at frequencies from 10 to 10,000 cps;
- 0.015 per cent ozone by volume at 600 deg F for 20 hours;
- sand, dust, salt spray, and humidity according to Mil-E-5272 Procedure I.

A filament transformer and a signal transformer both showed good electric characteristics and mechanical ruggedness. The former has been tested successfully to 932 deg F. It is a hermetically sealed stainless steel package using ceramic terminals with coated nickel feed-through conductors. The terminals are silver-brazed to the case by induction heating; the leads are silver-brazed to the terminals and to the coil conductor by a torch.

The core material is AISI M6 annealed silicon steel. The impregnating compound is an aluminum phosphate solution. The filling compound is a mixture of magnesium oxide, aluminum oxide, and aluminum phosphate solution.

The coils are wound with silver wire with a double glass covering. The spool is aluminum-phosphate-bonded muscovite mica paper. The

more on page 78



DoALL announces ELECTRO BAND MACHINING*

...a new and better means for slicing honeycomb metals

With this new development DoALL has solved one of the most irksome machining problems—that of cutting and producing fine finish on honeycomb of aluminum, stainless steel or titanium foil as well as other thin-wall metal structures such as heat exchanger cores.

Electro-Band Machining is an extension of the band sawing technique. A modified DoALL band machine uses a special saw band which is energized with low-voltage, high-current electric power.

QUENCHED ARC CUTTING

As the saw edge moves into the metal, an electric arc melts the thin sections while a flood of water quenches the arc and limits the heat. Resulting finishes can be attained to a flatness range of plus or minus .003 in. T.I.R. or plus or minus .016 in. T.I.R., depending upon cutting rates which range from 5 to 200 sq. in./min.

With Electro-Band Machining you can now start with a "log" and slice off pieces to accurate dimension and final finish rapidly and at low cost. The need for grinding core flat can be eliminated.

Electro-Band Machines are available in three sizes to accommodate work ranging from 12 to 48 in. in thickness. Insulated worktables are hydraulically operated; table feed rate and voltage to the cutting band are variable to meet job requirements.

For further details, call your local DoALL store or write for literature.

Slab of stainless steel honeycomb is cut to 5/16 in. thickness at a rate of 50 sq. in./min. The flood of water confines arcing, resulting in a finish equivalent to that produced by grinding.

*Patent applied for.

B-62

THIS IS A TYPICAL DoALL STORE

The DoALL Company, Des Plaines, Illinois

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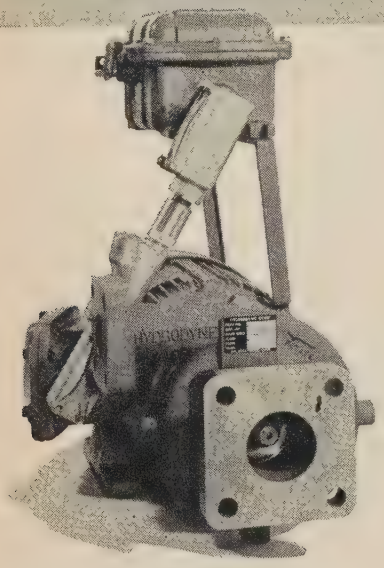
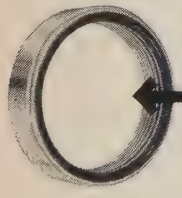
an EFFICIENT HYDRODYNE PUMP for CRYOGENY



Hydrodyne makes many types of hydraulic and pneumatic products . . . such as the cryogenic pump shown here. This particular pump, utilizing the famous Skinner Precision Bellows Seal, is designed for heavy duty cryogenic applications. These pumps have a capacity range of up to 1500 gpm. No heat transfer problem. Pump components are of various materials according to application. Illustrated is a Hydrodyne pump of this series with a capacity of 150 gpm, 20-foot rise, 6-foot suction head (NPSH), 2½-inch suction and 1½-inch discharge.



the SKINNER ROTARY METAL BELLOWS SEAL

An all metal bellows of various steel or nickel alloys, made with the sealing faces and mating rings of carbons, alloys, ceramics, and other materials, to meet specific temperature, corrosion and pressure requirements. Temperature range of —400°F to 1200°F; pressure range, 0 to 10,000 psi; and speeds to 80,000 rpm. Made by Hydrodyne's Skinner Seal Division.

hydrodyne CORPORATION

7350 Coldwater Canyon, No. Hollywood, Calif.
Phone: POplar 5-8001

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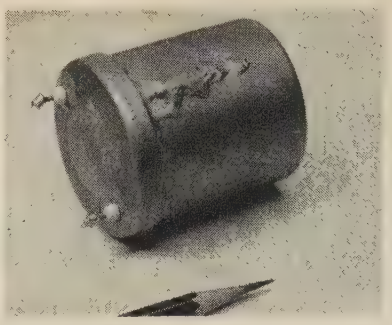


EXPERIMENTAL 100-mh air-core inductor.

sheet insulation is phlogopite mica paper.

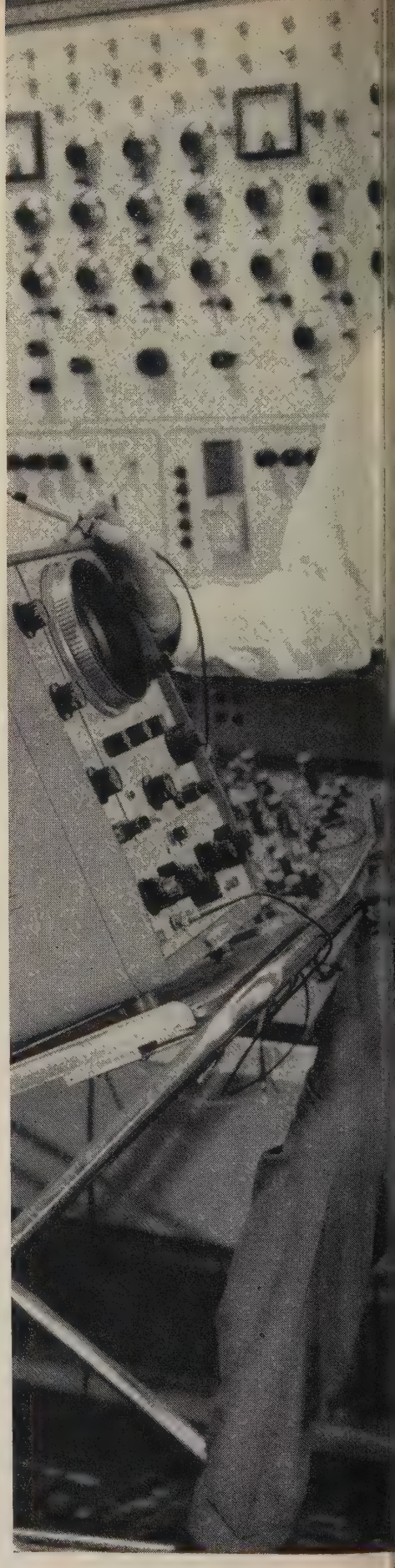
No-load to full-load control of the signal transformer at 620 deg F is 1.79 per cent. The total variation of the secondary voltage at full load from —65 to 620 deg F is two per cent.

The inductor tested by Sundstrand is an air-core type suitable for use in a tuned circuit with a 3200-cps excitation frequency. Its coil is wound on a glass-bonded mica bobbin, using #34 nickel clad copper wire with flexible ceramic enamel insulation. As the coil is wound, the wire is painted with a silicate-based cement, which is also used to fasten the coil in a stainless steel container. Silver solder with a 1200 deg F melting point is applied with a torch to fasten the ceramic-metal terminals to a stainless steel cover and the cover to the container.

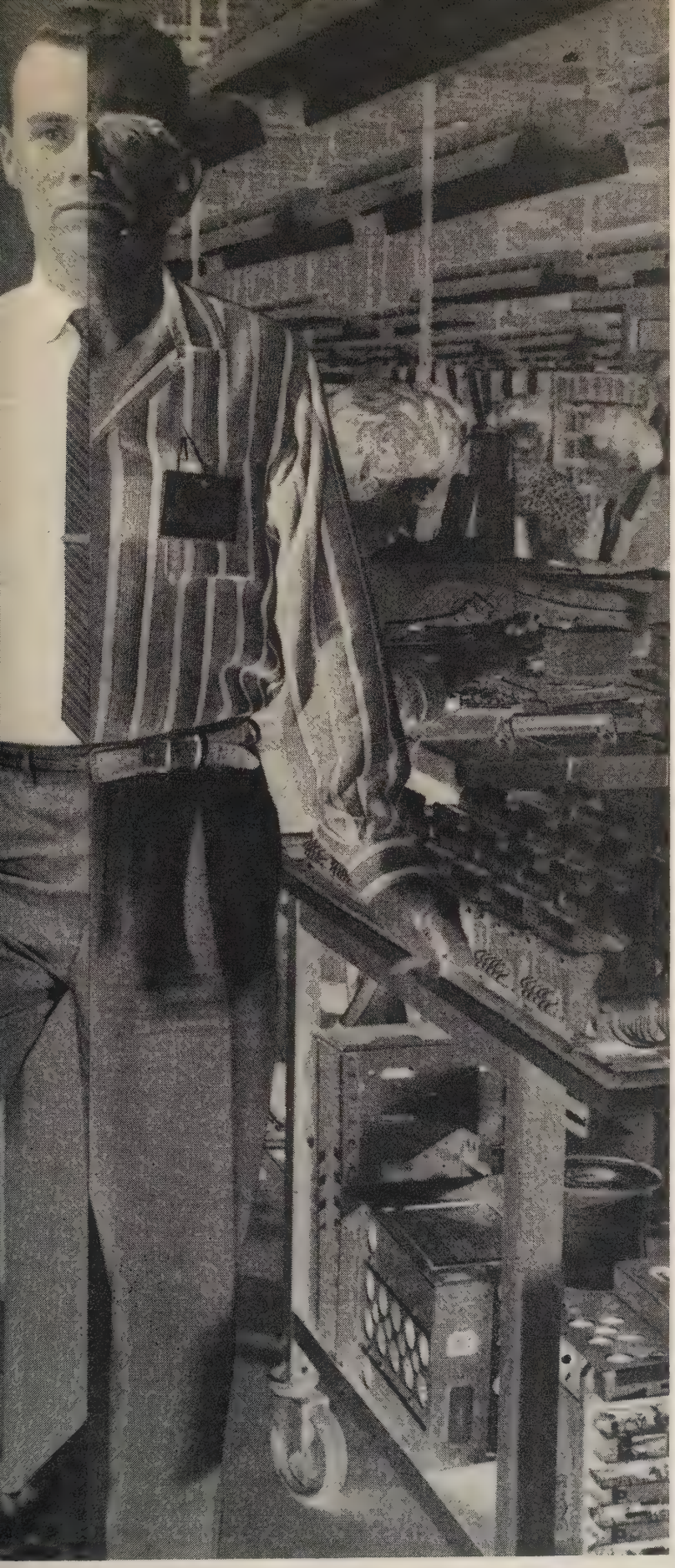
A 100-mh inductor showed a linear inductance change of six per cent —65 to 650 deg F. As inductance increases temperature goes up while capacitance decreases at the same time (as is shown by capacitor tests), these variations with temperature tend to cancel out when the two types of parts are used together in a tuned circuit. Tests of tuned circuits showed a tuned frequency variation of less than ±1 per cent from —65 to 600 deg F.

In our environmental tests, only one compound showed adequate strength and bonding action and didn't shrink too much—a chemically setting silicate-base cement in a two-part mix of a powder and a liquid binder. As the parts embedded in the compound are sealed in a stainless steel container, it doesn't matter that this cement tends to absorb water. High density and a 20-hour cure cycle that requires temperatures of up to 600 deg F

more on page 82



MOTOROLA



CLOUD 9 & ASSEMBLY LINE

RELIABILITY is designed into Motorola military electronic systems and equipment from the beginning... not patched on later...an inherent characteristic of all Motorola products for three decades. From *cloud nine to assembly line,* from original concept to completed military contract, uniform, dependable performance under severest operational environments is more than an objective...it is an obsession at Motorola. This spirit motivates 850 top scientists and engineers and more than 3000 technical specialists in all, deployed at Motorola's six wholly-owned facilities, exclusively engaged in electronics for defense.

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- Electronic Warfare & Countermeasures Programs
- Anti-Submarine Warfare Systems & Equipment
- Applied Research & Development in Microelectronics
- Advanced Radar & Sensor Developments
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- Navigation Systems & Equipment
- Surveillance Systems

For more detailed information, a comprehensive brochure will be mailed on request.

Qualified technical personnel are invited to join recognized leaders in many fields of science at Motorola...and share in solving complex military electronics research, development and production problems. Write to the area of your choice.

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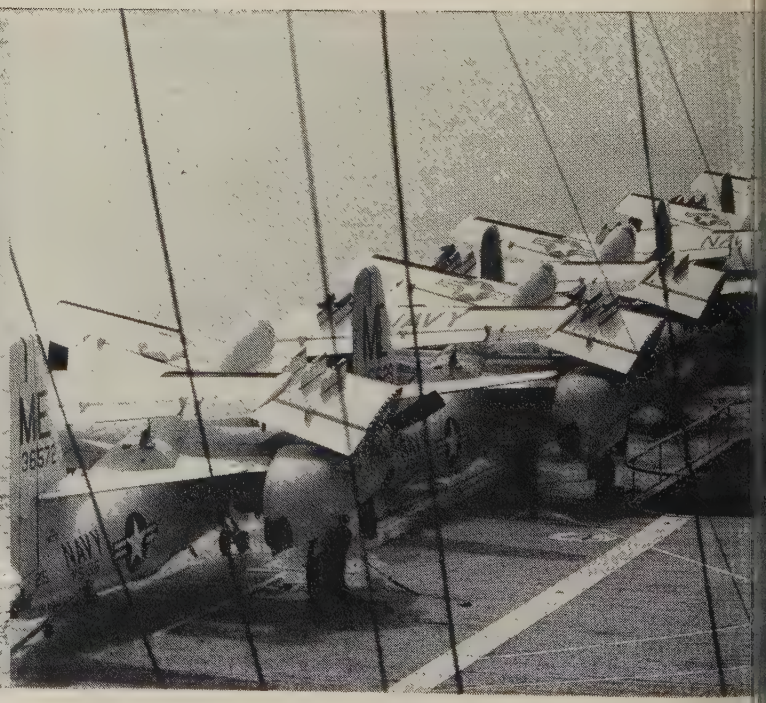
The story of Alfa and the Skunks—

An enemy might be able to hit any point in the United States with a missile fired from a submarine. To protect us, the Navy must patrol millions of square miles of open sea. Task Group ALFA trains for the task. Ships and planes probe the bottom of the seas in an eerie game of cat and mouse with sonar sets so delicate they must tell a school of snapping shrimp from a pack of enemy "skunks," as unknown submarines are called. Our anti-submariners depend on steel—carbon steel, high-strength low-alloy steel, ultra high-strength alloy steels, Stainless Steel,

With deadly patience, a helicopter hovers above a suspected submarine and lowers a sonobuoy into the water. Little larger than a football, the sonobuoy transmits any sound impulses from sub back to the helicopter, which can drop depth charges. The cable is specially designed multi-control electrical cable of steel and copper strands manufactured by the American Steel & Wire Division of U. S. Steel. It is the main artery of $1,000,000 worth of detection gear in the helicopter.



These S2F "Guardians" are ideal for long-range, all-weather operations. Engine pods hold sonobuoys; on the wings are seven-million-candle-power JULIE searchlights. It takes 78,000 tons of steel, counting the carrier and her supporting destroyers, to keep the task group's aircraft operating.

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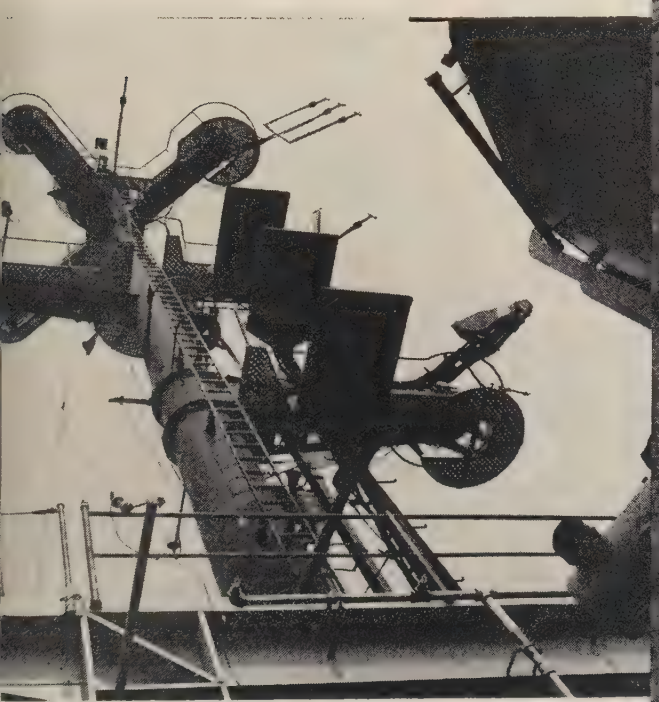
electrical cable, or wire rope. And United States Steel maintains the technical service to guide users in the proper use of these many steels and provide even better steels for the future. Before a program is ready for the drawing board consult with UNITED STATES STEEL.

USS **United States Steel**

TRADEMARK



CARRIER VALLEY FORGE's steel mainmast is a maze of electronic devices, including steel radar and radio antennas that keep her in constant touch with all elements of the task group. Her radio can reach around the world. She coordinates all attacks, and has been modified to handle anti-sub helicopters, S2F "Guardian" and AD "Skyraider" hunter-killer aircraft. Although not suited to handle modern Navy jets, VALLEY FORGE's life has been extended by modification to anti-sub work.

hma

COMPLETE CAPABILITY

HEAT EXCHANGERS

Advanced-type HMA cold-plate heat exchangers are setting new standards of superior performance at low over-all costs. Greater effectiveness and lighter weight . . . reasons why compact, highly-producible HMA air-heat sinks are a popular choice for more efficient heat transfer. Also, HMA customers get single source responsibility, as HMA designs, manufactures (including dip-brazing) and tests in its newly-expanded facilities. Precision units can be supplied to meet your specific requirements.

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horkey-moore associates

24660 Crenshaw Boulevard

Torrance, California / SPruce 5-1211

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are more troublesome.

A very similar silicate-base material in a one-part paste mix is satisfactory in coats of 1/16 in. or less. Lead wire breakage due to vibration is eliminated by applying a 1/16 in. coating of this compound to the lead wire from the soldered terminal to a point including 1/4 in. of lead wire insulation.

We also tested a very low density compound that has a filler of hollow ceramic spheres in a phenolic binder. While it shows good electric properties at high temperatures, it doesn't have enough cohesive strength to support embedded parts properly during high temperature vibration.

Wire from several suppliers proved suitable for 650 deg F ambient. Most of the hookup wire that we tested was nickel-clad copper (both stranded and solid). Silver-coated stranded electrolytic copper wire was also evaluated. Neither wire showed any disadvantages over the other.

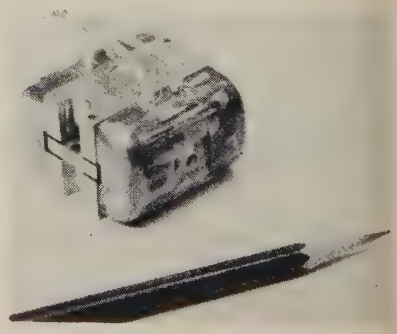
The hookup wire insulation types that withstood our test conditions were:

- a Teflon layer covered with impregnated glass braid;
- layers of treated felted asbestos, glass braid, Teflon, and impregnated glass braid;
- Teflon or silicone-treated glass braid;
- Teflon and glass covered with Teflon-impregnated glass braid.

Except for a loss of color coding in some cases, none of the wire samples deteriorated in any way during testing. Most suitable among the wires we tested is a stranded, nickel-clad, copper wire with Teflon insulation covered by impregnated glass braid—it has a small overall diameter, low weight, and good flexibility. Its dielectric strength at room temperature is

more on page 84

TORQUE MOTOR for 650-deg F operation.

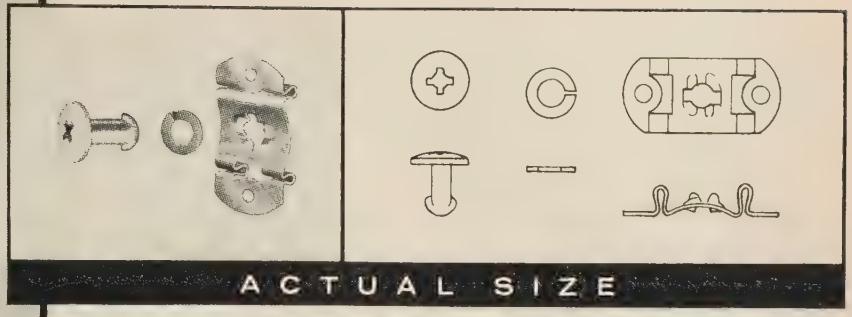


Now...

miniature

¼ turn

fasteners!



LION *miniature* FASTENERS

¼ TURN OPEN • ¼ TURN CLOSED

LIGHTWEIGHT • STRONG
MINIMUM ENVELOPE

A new size has been added to the Lion family of quick-opening fasteners . . . a miniature size. Small, compact, yet strong and rugged, these miniatures aid in reducing overall dimensions and weight without sacrificing the important advantages of larger Lion Fasteners.

ALIGNMENT NOT CRITICAL

Stud "floats" to accommodate misalignment. The hole in the sheet for the stud has an area 60% greater than the stud diameter. This allows a .030 float in all directions.

WIDE VARIATION IN STACK HEIGHT

Six different studs accommodate total material thicknesses (both sheets) of .040 minimum to .159 maximum.

Total sheet thickness served by any one stud may vary as much as .019 without affecting operation. A Lion Miniature Stud, specified for a thickness of .0863, for example, will accommodate total sheet thicknesses from .080 to .099.

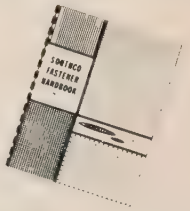
SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the exclusive Lion swaged nose design. All the metal is put to work. There are no holes, thin cross pins, or milled slots to weaken the cross-section. Case hardening assures long, trouble-free service without wear.

LARGER SIZES AVAILABLE

Lion Fasteners are also available in two larger sizes—No. 5 (mil spec) and No. 2—to meet the needs of aircraft, missile and ground support equipment. The heads are supplied in a wide variety of styles including oval, flush, wing, ring, notched and knurled.

FREE!



FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and many other special fasteners.

Write to Southco Division, South Chester Corporation, **253** Industrial Highway, Lesier, Pennsylvania.

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LION *Aviation* FASTENERS

one of the

SOUTHCO LION **FASTENERS**

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7000 V; at 650 deg F, it is more than 2000 V.

Nickel-clad copper magnet wire with a flexible ceramic enamel coating was used successfully for an inductor coil. Wound on a ¼-in.-diameter rod, it showed no crazing (in contrast to other ceramic-insulated magnet wires). Its dielectric strength is 300-700 V/mil and its resistivity at 600 deg F about 30 ohms per circular mil-ft.

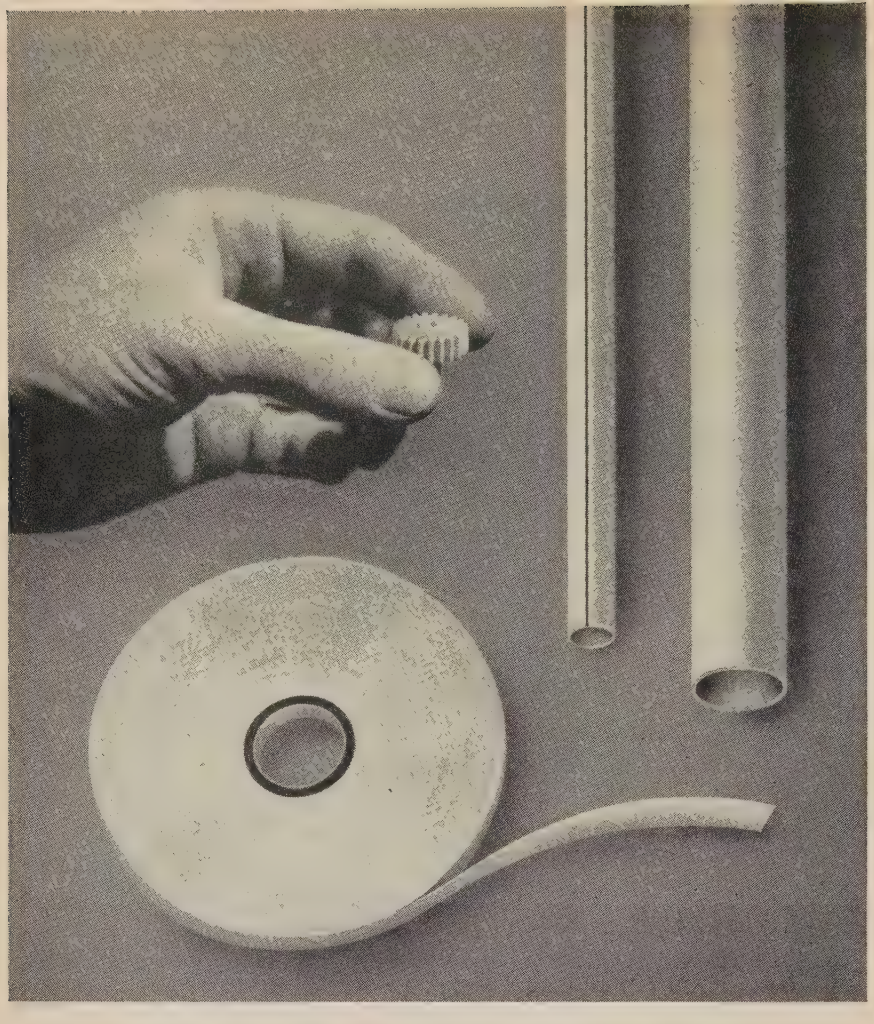
The dc torque motor of our constant-speed drive control system was successfully run through all our environmental tests except those for ozone, sand, dust, salt spray, and humidity. It has a nonrotating, flat armature held by torsion bars between four permanent magnets coupled to two electromagnet coils. When direct current passes through the coils, the armature turns until the restraining force of the torsion bar shaft equals the applied magnetic torque. Armature deflection is about ±0.008 in. and is linear over this range.

The permanent magnets are Alnico V. The motor frame is nonmagnetic stainless. The torsion bar shafts are hardened stainless brazed onto the armature at one end and into the frame on the other. The armature and the two pole pieces are machined from 50 per cent nickel-iron alloy.

Two coils of nickel-clad ceramic insulated copper wire are wound on aluminum coil bobbins with high temperature sheet insulation. The coils are encapsulated in a high temperature cement, which also holds them in the motor. Stranded copper lead-out wires are silver-soldered to the coil wire and fastened mechanically to the coil before encapsulation.

The installed torque motor is enclosed in a nitrogen atmosphere and partly or wholly covered by a disiloxane or chlorinated silicone hydraulic fluid at temperatures up to 650 deg F. At the high temperature, up to 10 per cent degradation in performance is noted.

Terminals are readily available for 600 deg F operation. Their bushings are made of alumina ceramic. Flanges and tubes are fastened by brazing to the metallized alumina bushings. They are made of nickel-iron alloy or monel, which have coefficients of expansion that are close to the coefficient for ceramic. These terminals can be safely brazed into component containers at about 1500 deg F.—End



Small part, large part, structural or insulating—or the standard unfabricated forms—if it's "Teflon," then R/M is the place to get it fast.

For component miniaturization, THINK "TEFLON" from R/M

One way to smaller electrical conductors and other high-heat components, as you know, is through "Teflon"* insulation. In fact, there's just no substitute for the fluorocarbons in many critical applications.

It will pay you to call on the experience of R/M in processing "Teflon" into rods, sheets, tubes, tape, bondable "Teflon," and machined aircraft parts. R/M offers *complete "Teflon" service* backed by unmatched "Teflon" know-how. When you think "Teflon," remember the facilities of R/M to produce and deliver in production quantities to your specifications.

Call your nearest R/M district office (listed below) for further information on R/M "Teflon" service. Or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

*Du Pont trademark for its TFE-fluorocarbon resin

PLASTIC PRODUCTS DIVISION
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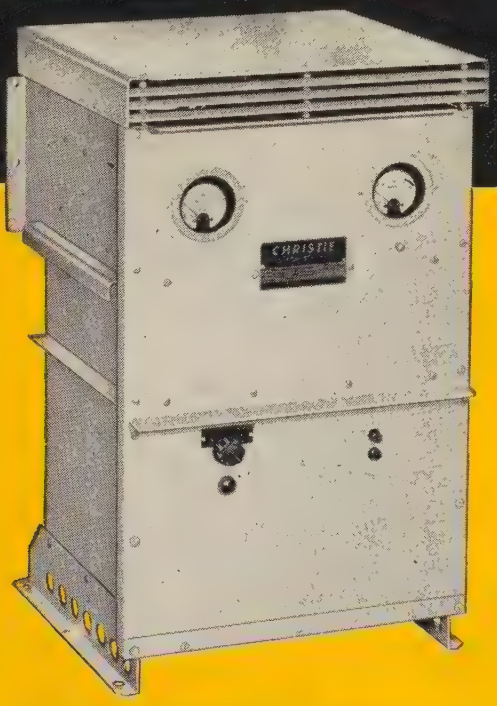
CHRISTIE®

Specialists in Power Supplies for 30 Years

D-C POWER



WITH ENGINEERED AND CONTROLLED

RELIABILITY

- Static-Tubeless
- All Silicon
- Built to MIL-E-4970
- Overload and Short Circuit Protection
- 500% Overload Capability

Write for new D-C Power Supply Bulletin AC-60

CHRISTIE ELECTRIC CORP.

3402 W. 67th Street, Los Angeles 43, California

300 AMP. POWER SUPPLY

Model MH32-300KP4

Electrical Specifications:

NOMINAL D-C OUTPUT:
28 v. @ 300 amp. (continuous)

VOLTAGE ADJUSTMENT RANGE:
22 to 32 v. d-c

VOLTAGE REGULATION:
±0.5% — combination of rated load and a-c input variations (Sensing: local or remote)

VOLTAGE RIPPLE:
1% rms. (—20°C to +55°C)

VOLTAGE RECOVERY (63%):
0.1 sec.— full load application or removal

D-C CURRENT OVERLOAD CAPACITY:
125% for 5 min. every 20 min.
250% for 5 sec. every 20 sec.
350% for 1 sec., 500% peak

A-C INPUT:
400-490 v., 3-ph., 57-63 cps.
(other voltages available)

A-C CURRENT AT 440 V.:
9 amp.

AMBIENT TEMPERATURE RANGE:
Operating: —55°C to +55°C
Storage: —62°C to +70°C

ENVIRONMENT, SHOCK, VIBRATION:
Built to MIL-E-4970

RADIO INTERFERENCE:
Built to MIL-I-26600

Mechanical Specifications:

CABINET STYLE: STATIONARY
Also other styles below

SIZE & WEIGHT:
19" W x 19" D x 31" H.— 355 lbs.

Standard Features:

VOLTMETER & AMMETER:
3½" ruggedized (MIL-M-10304)
Recessed behind removable panel

OVERLOAD PROTECTION:
Magnetic & thermal

PARALLEL OPERATION:
Includes load sharing provision

OTHER FEATURES:
Input Contactor, Pilot Light, Fan, Fan Failure Protection.

Over 200 Models in 6 Cabinet Styles

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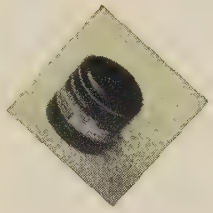
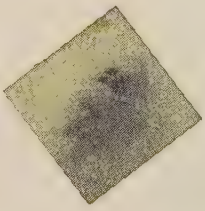
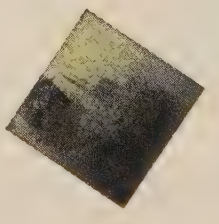
COMPONENT KNOW-HOW
THE KEY TO SYSTEMS CAPABILITY



In systems development there is no substitute for experience in component and subsystem design. For more than five years, Daystrom Pacific has been providing gyroscopes, transducers and other basic building blocks for major airborne and missile systems. The development of equally reliable airborne instrument systems has further enhanced Daystrom Pacific's over-all capability.

Backed by its parent organization, Daystrom, Inc., the company has expanded its airborne instrument and subsystem work to include systems development programs that require the competency of an outstanding technical team... the thinking and abilities of an advanced planning group.





If you are responsible for the development of a major systems program, you will be interested in Daystrom Pacific's experience and systems capability. Write for our new engineering brochure—File No. SA-876-2.

Openings exist for qualified engineers.

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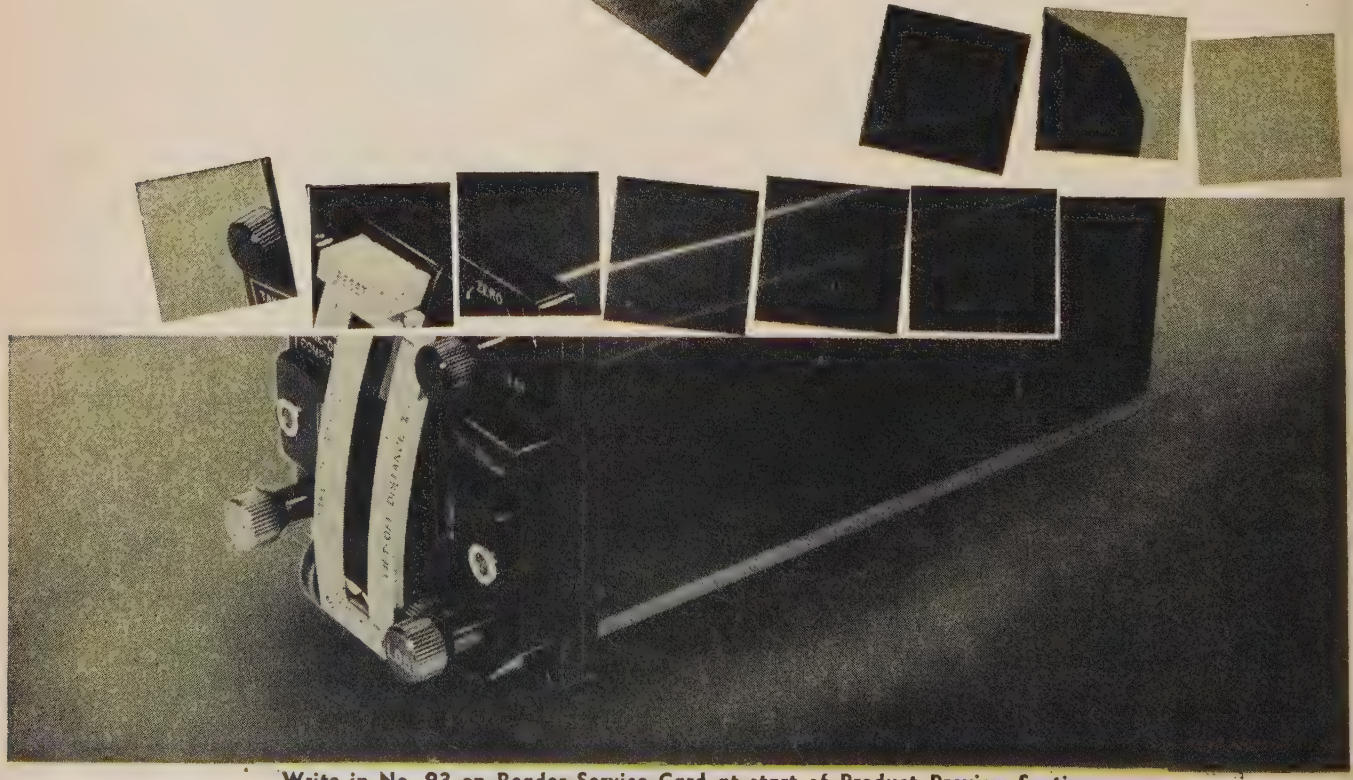

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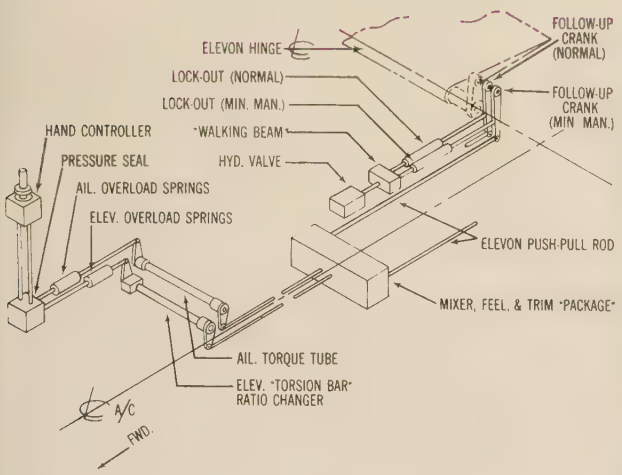
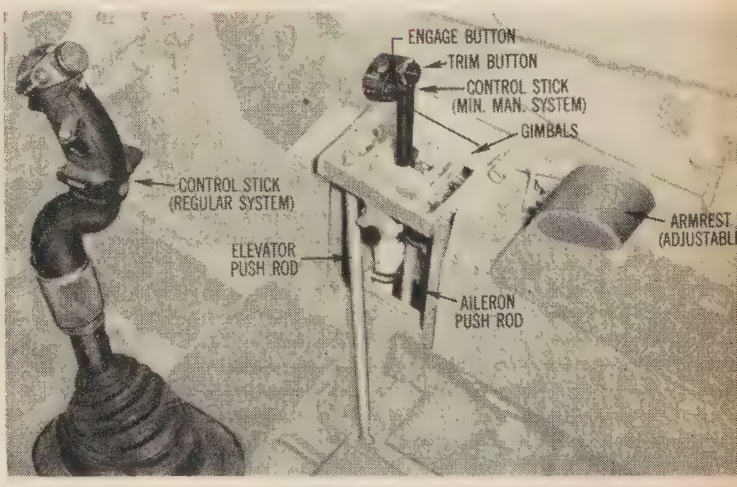




MINIMUM MANUAL control system (left) is based on a very simple design. Right: Minimum manual controller has a trim button to correct unbalanced flight loads and an engage button for transferring control from one system to another. The double gimbal installation has one gimbal connected to aileron-action linkage for lateral movement of the controller, the other to elevator-action linkage to permit fore-aft motion.

Minimum manual controls:

stepping stone to the "electric stick"

An electric controller is the prime hope for solving the problem of maneuvering supersonic military jets. The first step in this direction is the development of a light and simple manual backup system.

by Bjorn O. Andreasson,

Design Group Engineer, Convair-San Diego*

THE stability and control problems involved in maneuvering the modern military jet demand a highly sophisticated automatic control system backed up by a simple and light manual system. The most promising automatic system is a miniature "electric stick" controlling a closed-loop electric control system. It could be operated by the pilot with negligible muscular effort and would allow the design engineer to use a wide variety of system characteristics to meet the large variations in speed and air density.

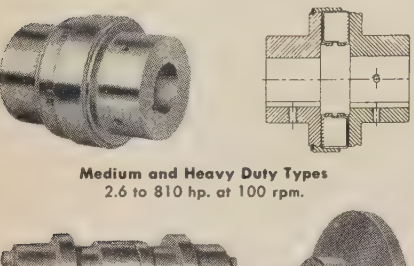
Despite the many advantages of the electric system, the present state of the art does not justify the complete

more on next page

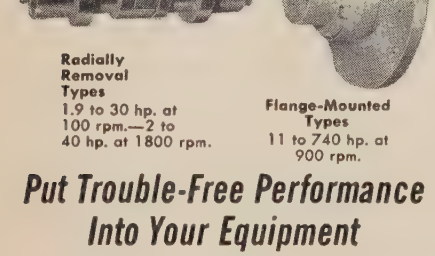
* Convair Div., General Dynamics Corp., San Diego 12, Calif

Lovejoy

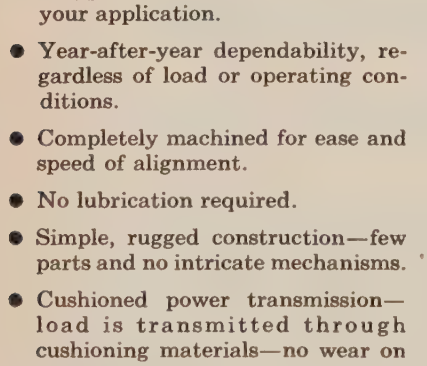
Maintenance-Free
FLEXIBLE
COUPLINGS



Standard Duty Types
.05 to 40 hp. at 1750 rpm



Medium and Heavy Duty Types
2.6 to 810 hp. at 100 rpm.



Radially Removal Types
1.9 to 30 hp. at 100 rpm.—2 to 40 hp. at 1800 rpm.

Flange-Mounted Types
11 to 740 hp. at 900 rpm.

Put Trouble-Free Performance Into Your Equipment

COMPARE THESE FEATURES:

- A type and size perfectly suited to your application.
- Year-after-year dependability, regardless of load or operating conditions.
- Completely machined for ease and speed of alignment.
- No lubrication required.
- Simple, rugged construction—few parts and no intricate mechanisms.
- Cushioned power transmission—load is transmitted through cushioning materials—no wear on the metal jaws.
- Double-life cushions—one half the cushions act as idlers, except on reversing loads—quick interchange provides a new set of cushions.
- Cushions are engineered to the load and service conditions.

Ask Lovejoy to recommend the exact flexible coupling for your application. No obligation. Request catalog.

LOVEJOY FLEXIBLE COUPLING CO.

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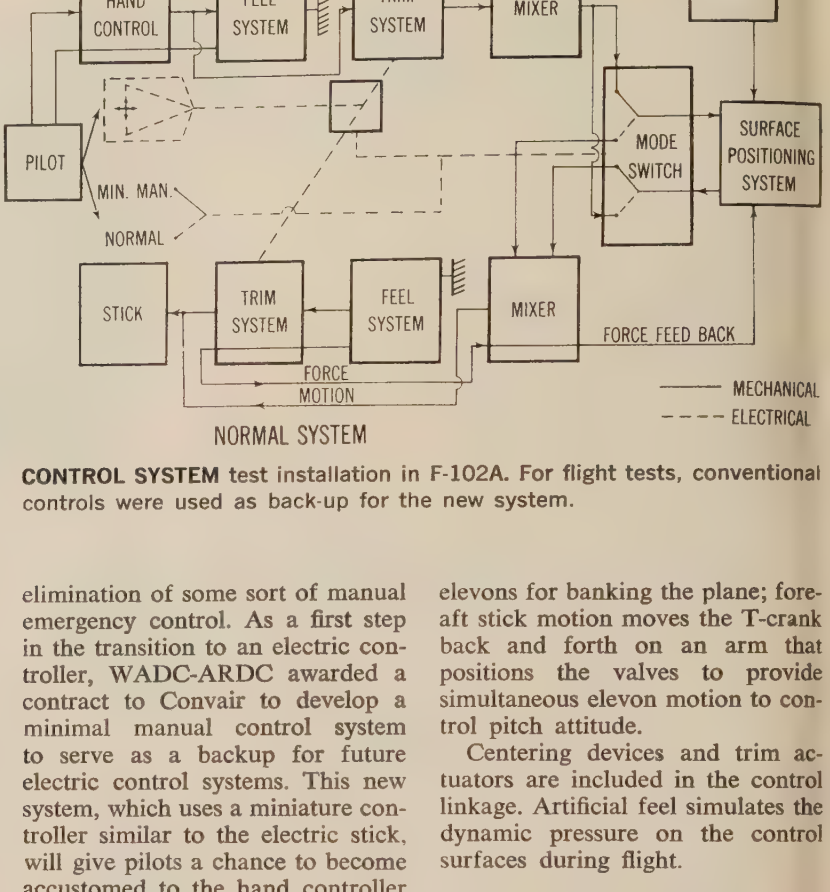


CONTROL SYSTEM test installation in F-102A. For flight tests, conventional controls were used as back-up for the new system.

elimination of some sort of manual emergency control. As a first step in the transition to an electric controller, WADC-ARDC awarded a contract to Convair to develop a minimal manual control system to serve as a backup for future electric control systems. This new system, which uses a miniature controller similar to the electric stick, will give pilots a chance to become accustomed to the hand controller while they still have the conventional stick available. It was to be installed in an F-102.

The regular F-102 flight control system consists of mechanical connections between the flight controls and two dual hydraulic valves that port hydraulic fluid under pressure to the dual actuating cylinders for the elevons. Follow-up devices close the valves when the control surfaces reach the position indicated by the pilot's controls. Pressure to power the control system is provided by two independent hydraulic systems; a stand-by pump, driven by a ram-air turbine, is available in case of a complete powerplant failure.

In the F-102, each elevon is operated independently by a hydraulic valve that regulates the flow of hydraulic fluid to its actuating cylinder. A mechanical mixer is included in the control linkage and separates the fore-aft and side-to-side movements of the control stick to produce the proper elevon action. Side-to-side motion rotates a T-crank that adjusts the valves to impart a differential motion to the elevons for banking the plane; fore-aft stick motion moves the T-crank back and forth on an arm that positions the valves to provide simultaneous elevon motion to control pitch attitude.

Centering devices and trim actuators are included in the control linkage. Artificial feel simulates the dynamic pressure on the control surfaces during flight.

Interconnection of systems posed problems

In interconnecting the regular and minimal control systems, it was necessary to provide for:

- completely independent operation of each system;
- immobilization of one system while the other is in use;
- continuous duplication of the movements of the active control by the control of the inactive system;
- a convenient way of changing from one system to the other;
- synchronization of the trim settings of the two systems to prevent abrupt attitude changes in switching from one to the other.

In addition, a drastic reduction in system size and weight was called for as well as a reduction of friction far below the value for any known conventional system. Finally there was the problem of finding room to install another control system in the F-102.

The minimal manual system parallels the conventional manual control from control stick to the

more on page 92

DOW *Now in magnesium and aluminum*

ARE YOU GETTING ALL THESE BENEFITS WITH YOUR MAGNESIUM CASTINGS?

Dow magnesium foundry offers experience, production capacity for sand and permanent mold castings of all sizes and shapes.

The unique capabilities of Dow's Bay City, Michigan, foundry help users of magnesium sand and permanent mold castings. Activities at this facility—largest and best equipped of its kind—run the gamut from large volume production jobs to one-shot "specials."

Huge or tiny castings. The foundry is capable of producing castings weighing in excess of 3,000 lbs. down to ounces—in all degrees of complexity. Experienced pattern engineers ensure that the best use of casting processes is made. This can result in either lower costs, improved quality, better deliveries, or a combination of all three.

Newest techniques. Many milestones in magnesium casting have been reached at this Dow foundry. In fact, Bay City has men permanently assigned to developmental work, keeping the foundry in the forefront of technological advances at all times.

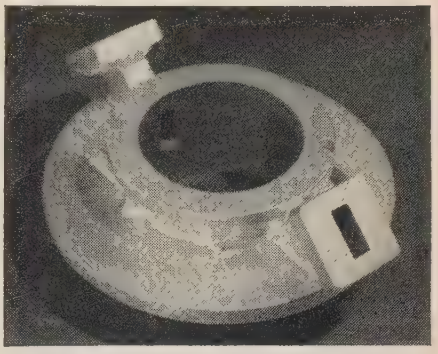
Results of their work include special processes for cast-in inserts and tubeless passages, and improved melting techniques. Casting methods have been developed for many of the newer magnesium alloys, such as the elevated temperature group and the new high damping capacity alloy, K1A.

Quality control. A full time quality control team exhaustively checks all work, from alloy composition to the shipping dock. A direct-reading spectrometer makes rapid alloy composition analyses. Its speed is particularly valuable when alloying elements that are hard to hold in the molten state, such as thorium, are present. Chemical analysis is also frequently employed.

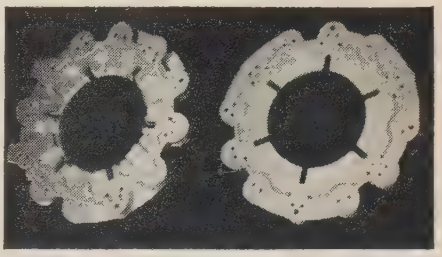
Testing facilities. Molding and sand cores are analyzed as a regular part of casting quality control. Radiography, fluorescent penetrant inspection and other testing facilities are used to check properties and specifications.

Experienced magnesium team. The foundry often draws upon the broad range of specialized experience available throughout the company. To Bay City customers, this means assurance of high quality work, done with utmost efficiency and economy. If your requirements involve magnesium castings, Dow can help you arrive at optimum casting design and reliably supply your production requirements.

FOR MORE INFORMATION, contact your Dow Sales Office or write today for illustrated brochure discussing Dow foundry services. THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1001EW3.



THIS SAND CAST WAVE GUIDE was held to ±.005" on passageway dimensions. Surface smoothness requirements are 63 RMS. The foundry has government approval for any phases of its operations where such approvals are applicable.



THIS BRAKE CARRIER is sectioned to show how the hydraulic lines were integrated by use of tubeless passageway casting techniques.

DOW **THE DOW METAL PRODUCTS COMPANY**

Division of The Dow Chemical Company

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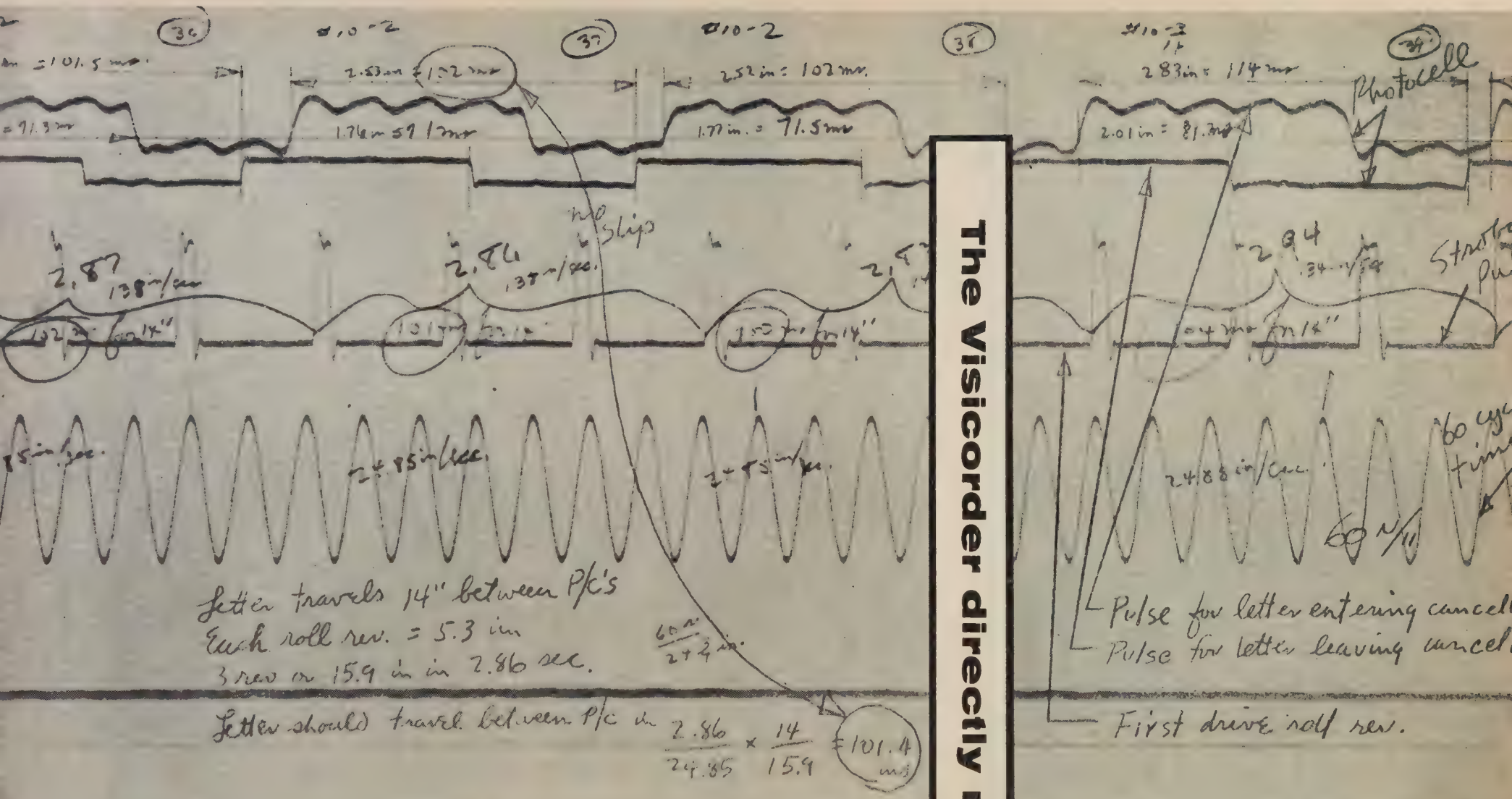

Letter travels 14" between P/c's
Each roll rev. = 5.3 in
3 rev in 15.9 in in 2.86 sec.
Letter should travel between P/c in
Photocell
Pulse for letter entering cancel
Pulse for letter leaving cancel
First drive roll rev.

Unretouched Honeywell Visicorder record, actual size.

The Visicorder directly records

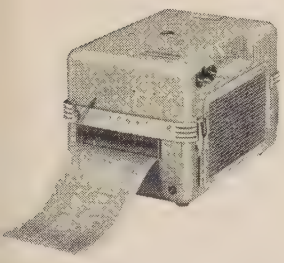
The Emerson Research Laboratories at Washington, D.C., directly-recorded this chart on a Honeywell Model 906 Visicorder. The chart shows a canceller test of a number of letters through a new mail-handling machine developed by Emerson for the U.S. Post Office Department.

In this test, the Visicorder took only 3 hours to reveal information that would have taken 3 weeks to get by any other means: what factors were responsible for the changing speeds of letters as they traveled through the machine at the rate of 30,000 letters per hour. Constant letter-travel speeds were necessary in order to register the cancellation mark on the stamp every time.

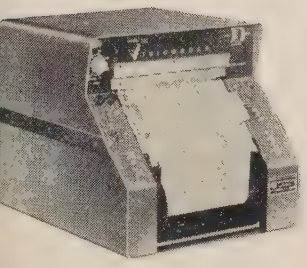
This Visicorder record revealed that motor speed variations, belt slippage and slippage of the letter in the drive rollers were responsible. A synchronous drive motor, a timing belt drive and a better grade of rubber in the drive rollers were added to solve the problem—at a vast saving in engineering time.

Milton Stovall, Emerson Project Engineer, uses the Visicorder to measure roller bounce caused by various letter thicknesses, and the consistency of letter speed through the new Emerson Automatic Mail Cancelling and Facing Machine.

high-speed letter travel



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.

The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder Oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: write for Bulletins 1108, 1012, and HC906B

Minneapolis-Honeywell Regulator Co.
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valves that control elevon operation. The conventional rudder controls are used with both systems.

The new system consists essentially of a miniature controller, a small mixer, and the push-pull and torque tubes and bell cranks needed to connect the controller with the hydraulic valves operating the elevons. Lightweight tubing is used throughout, and friction in the bearings has been reduced to the point where genuine finger-tip control is finally achieved. Even with the greatly reduced leverage, the effort needed to operate the controller amounts to only a fraction of that required to fly the plane with the regular control stick.

The controller is about four inches long and has two electric buttons—one for correcting unbalanced flight loads, the other for transferring control to the conventional system. A double gimbal lets the controller tilt freely in any direction within prescribed limits.

Overload springs protect the system

The separate aileron and elevator linkages carry commands from the controller to the mixer. Overload spring cartridges in both linkages limit the system load to about 200 per cent of normal load. The elevator linkage also contains a torque bar with a low spring constant. This unit serves as a variable ratio changer to reduce the sensitivity of the elevator action of the controller at high speed, when the dynamic loads on the control surfaces are greatly increased.

To give the desired elevon response, the minimal manual mixer, like the conventional one, integrates pitching and banking commands from the controller and relays the results to the hydraulic valves that control the elevons. A T-crank connected to the aileron-action linkage provides differential elevon position to bank the plane. The idler on which the T-crank is mounted is connected to the elevator-action linkage. A fore-aft motion of this idler causes the elevons to move in unison for pitching control.

The minimal mixer provides aileron feel through a spring-loaded cam that centers the controller laterally and generates a stick force proportional to the difference between the position of the two elevons. For elevator feel, too, a cam

more on page 94

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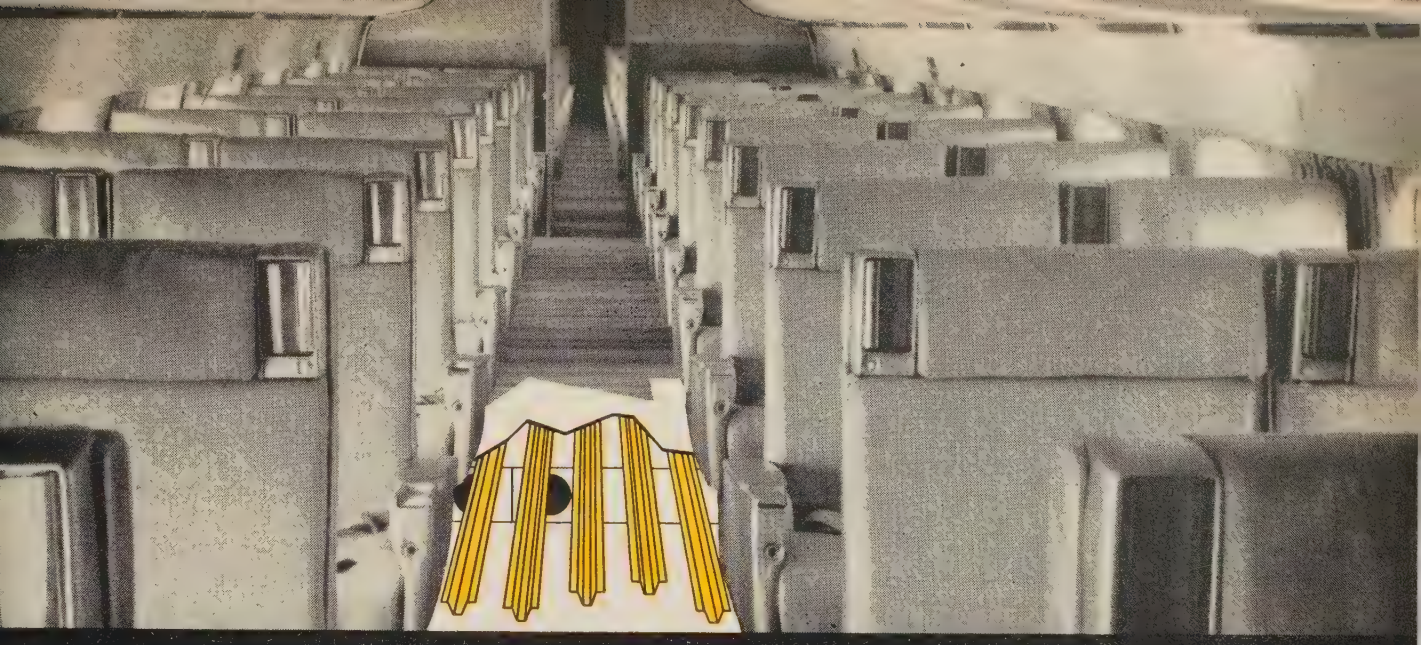

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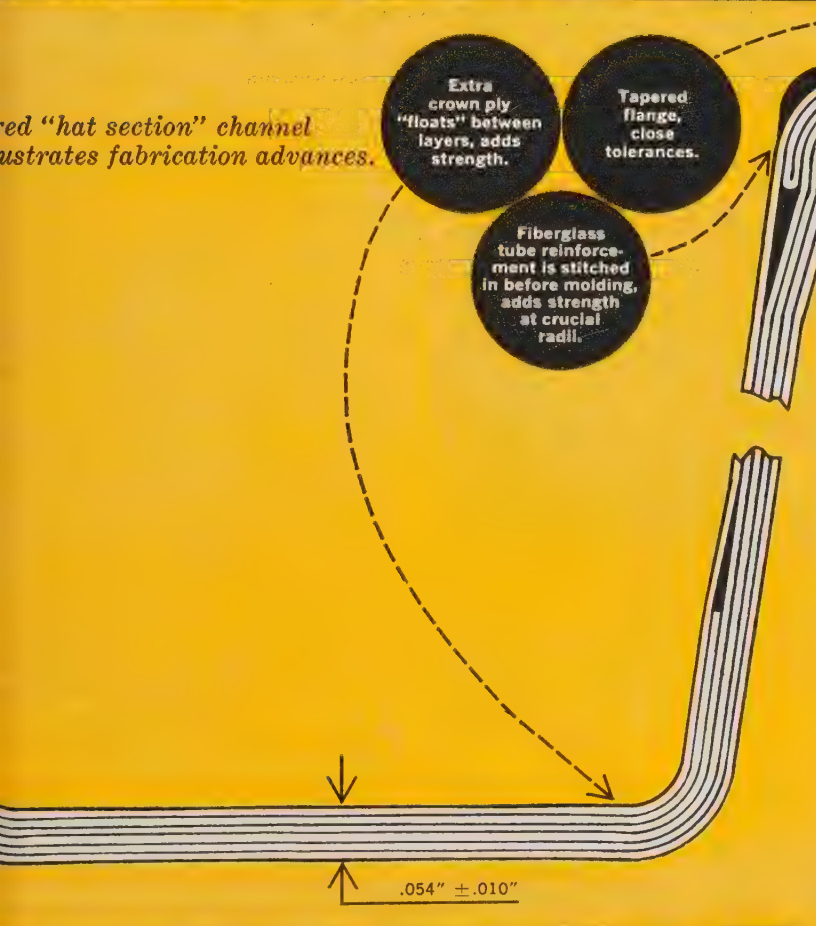
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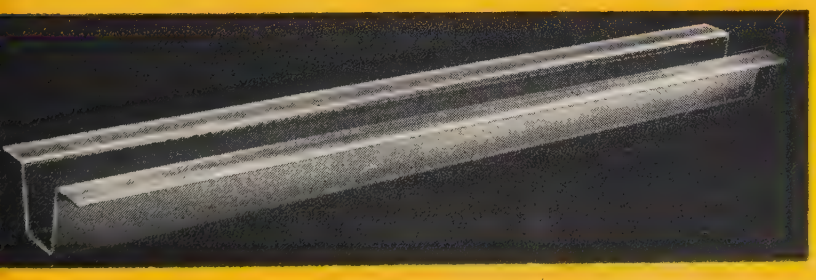

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To provide Douglas DC-8 cabin floors with thermal insulation as well as high strength and minimum weight, Swedlow is producing an unusual type of supporting channel using matched die techniques. Solving the producibility problem called for new methods of fabricating complex laminates. Swedlow's success is seen in this non-uniform cross section "hat" channel which replaces metal sub-flooring.

The material is multi-ply fiberglass cloth impregnated with a high temperature epoxy resin system. A difficult tapered flange and extra reinforcement at key points increase strength. Swedlow quality control assures close tolerances and good physical properties up to 300°F. This development of Swedlow skills and materials holds promise in many applications requiring high strength-to-weight ratios, temperature resistance and precise fabrication.

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Arnoux's new Decommutator provides greater dimension in telemetry, flexibility, and reliability.

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is used but only to center the controller fore and aft. The actual simulation of in-flight dynamic forces acting on the elevons is derived from a feel cylinder, or q-pot, containing a piston connected to the elevator-action linkage.

A feel-force regulator limits pressure

Dynamic pressure, generated by the plane's forward speed, is transmitted from a q-intake in the fin leading edge through a feel-force regulator to the chamber back of the piston in the feel cylinder. The elevator-action linkage is connected to the piston by a bell crank that forces the piston against the q-pressure whenever the controller is moved to either side of center.

The feel-force regulator limits the dynamic pressure in the cylinder to a value corresponding to an airspeed of about Mach 0.7. This prevents excessive controller loads at transonic and supersonic speeds. The maximum elevator force measured at the controller is about two lb/g, while the maximum force needed for full aileron deflection is only six pounds.

Aileron and elevator trim is provided by two trim actuators in the mixer aft of the feel devices. These actuators contain small, electrically driven screwjacks that change the length of the linkage and so the position of the elevon in relation to that of the controller. They are controlled by the controller-mounted trim switch. Since they're behind the feel and centering devices, they modify the control surfaces' positions without affecting the neutral setting of the controller.

Mixer output is transmitted to the elevon hydraulic valves through torque tubes and push rods, as well as a follow-up arm, a valve input rod, and a walking beam for each valve. The lower end of each arm is attached to the mixer ouput rod, the upper end to the elevon horn, and the center to the valve input rod.

The output of the regular mixer is transmitted to the elevon hydraulic valves through a similar mechanism running parallel to the minimal system. The follow-up arms of both systems are attached to the elevon horns by double bearings. The follow-up rods of each system are attached to opposite ends of the walking beams. The center of each walking beam is connected directly to the hydraulic valve.

Lockout valves next to each valve input rod can lock the rods of either system while the other is being used to fly the plane. They are controlled by the transfer switches on the regular control stick and the controller. These switches are connected electrically to a transfer valve that ports hydraulic fluid to the lockout devices. The transfer valve is designed so that only one system can be locked out at any particular time.

When the minimal system is being used, the valve input rods of the regular system are locked and movement of the controller will actuate the hydraulic valves by moving the free end of the walking beams. If the controller is moved aft, the minimal valve input rods move aft, too, and open the hydraulic valves. These port hydraulic fluid to the rear chambers of the hydraulic cylinders and move the elevon horns forward, raising the elevons. The elevon horns carry the upper end of each follow-up arm forward and move the valve rods back to their original position when the elevons have reached the position selected by the controller. The same positioning action follows any movement of the active control.

In operation, the steps in this follow-up action blend together to give a smooth response in which the elevons follow every movement of the control stick or controller. The linkage is designed so that full travel of the controller or control stick corresponds to full elevon deflection under the no-load condition.

The common attachment of the follow-up arms of the two systems provides a way to coordinate the movement of the two sets of controls. With the valve input rods of the inactive system locked, the follow-up arms pivot on their attachment to the rods. When the elevons move to a new position, the elevon horns rotate the arms about these pivots and cause the inactive control to assume the same position as the active one. Since the inactive system is positioned by the elevons, which are power-driven by the hydraulic cylinders, this feature doesn't impose any load on the active control.

An automatic pitch trim system is provided for transfer from one system to the other without abrupt change in attitude. A set of follow-up switches adjusts the trim of the

more on next page

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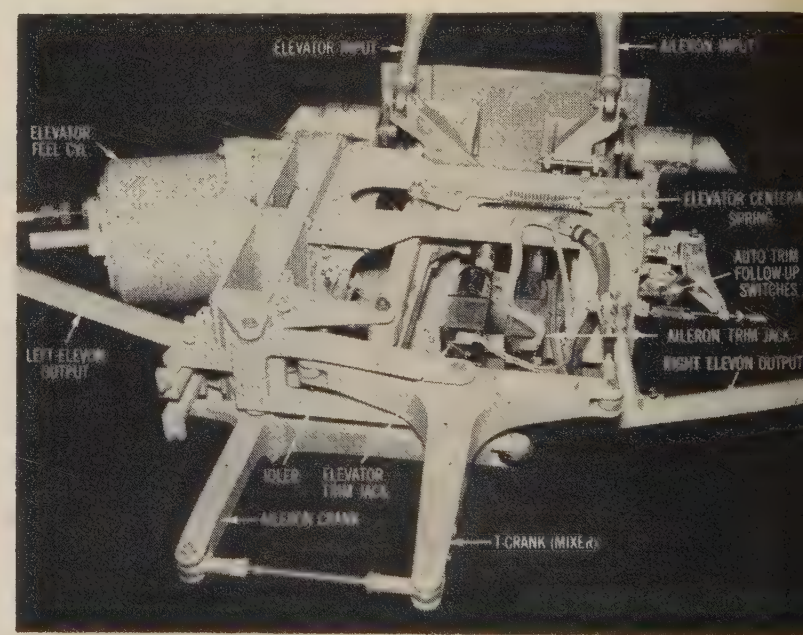
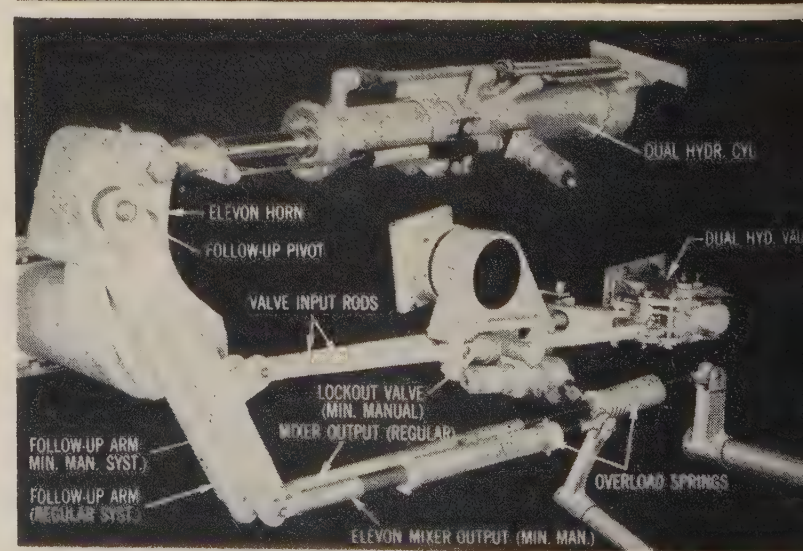
inactive system to reduce any load imposed by the q-pot.

After the first model had been installed in a test stand and tested for proper functioning, the next step was to "flight-test" the new system on the ground. The test stand was instrumented to present the pilot with tracking problems similar to those he would be confronted with in the air. The elevons were equipped with potentiometers, which feed surface position to an analog computer that simulates the resulting flight maneuvers and presents them on a scope as a moving horizon. A target dot is produced by a random noise signal. The plane is represented on the scope as a fixed horizontal line. Data from the computer are also fed to flight instruments.

Several pilots evaluated the new system and, in every case, were able to do a better job of tracking the target with the hand controller than with the regular stick. A number of Convair and USAF pilots were then given the chance to flight-test the new system. All agreed it was very easy to fly; in fact, some preferred it to the old system.—End

MINIMUM manual mixer (top) integrates pitching and banking commands from the controller. Bottom: Components of left-elevon operating mechanism. Follow-up arms make it possible to position the elevons according to the setting of controller or control stick and also cause the inactive system to duplicate every movement of the active one.





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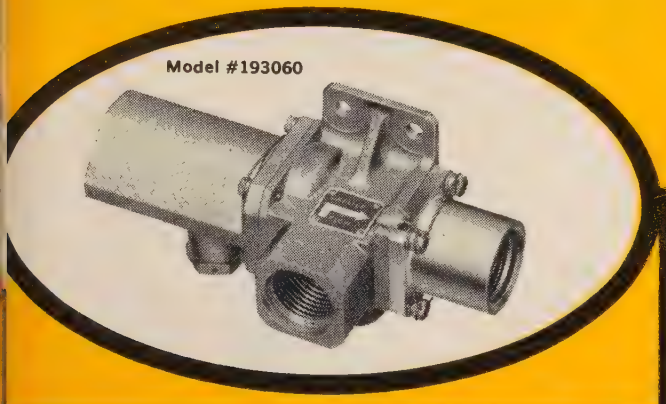

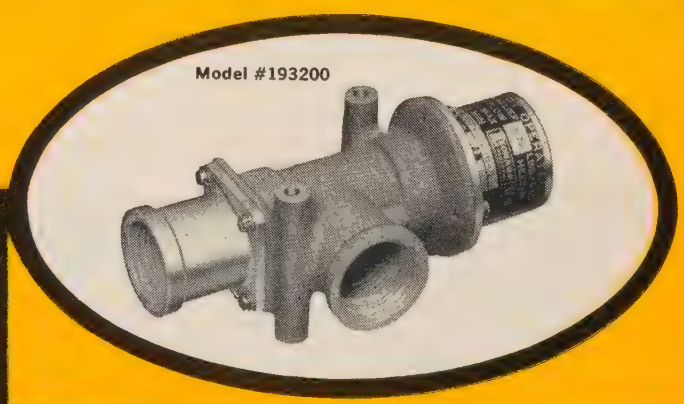

SPECIFICATIONS • MODEL #193060	
Media	Helium
Cracking Pressure	385 psig max.
Reseat Pressure	370 min.
Flow	.15 lbs/sec.
Leakage	55 cc/min @−320°F
Operating Temperature	−320°F to +200°F
Vibration	30 G 10 to 2000 cps
Acceleration	20 G's
Weight	14 oz.
Overall Length	5.40 in.
Response Time	5 ms. to full open

SPECIFICATIONS • MODEL #193200	
Media	Helium
Cracking Pressure	32 psig max.
Reseat Pressure	29 min.
Flow	.032 lbs/sec.
Leakage	5 cc/min @−320°F
Operating Temperature	−320°F to +200°F
Vibration	MIL-E-5272, Proc. 1
Acceleration	20 G's
Weight	14 oz.
Overall Length	6.00 in.
Response Time	5 ms. to full open

DESIGN PARAMETERS • MODEL #193060	
Maximum Flow	.36 lbs/sec.
Cracking Pressure	250 to 1000 psig.
Media	GOX, Hydrogen, Nitrogen, and other gases

DESIGN PARAMETERS • MODEL #193200	
Maximum Flow	.2 lbs/sec.
Cracking Pressure	30 to 250 psig.
Media	GOX, Hydrogen, Nitrogen, and other gases

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Predicting the creep strength of joints

Determining the creep strength of built-up structures like joints no longer has to be a matter of protracted testing. NBS researchers now have come up with methods for calculating this parameter from known properties.

by Randolph Hawthorne, Editor

FOR structural metals, creep usually becomes significant at several hundred degrees F above room temperature. At still higher temperatures, it so weakens these materials that they become useless for engineering purposes.

Little was known until lately about creep effects on built-up structures. In 1952, L. Mordfin, N. Halsey, and others at the Mechanical Engineering Section of the National Bureau of Standards, Washington 25, D. C., began a series of studies in this area. Under the sponsorship of NASA and BuWeps, these studies are still going on. Formerly, the design of joints for weight-sensitive structures called for some trial and error testing under the load and temperature conditions which would be imposed in use. NBS's studies have led to new methods with which you can now calculate approximate designs, so that less testing is necessary.

For finding the creep rupture strength of joints, NBS recommends a calculation similar to that for strength under static conditions. Two variables are added: time and temperature.

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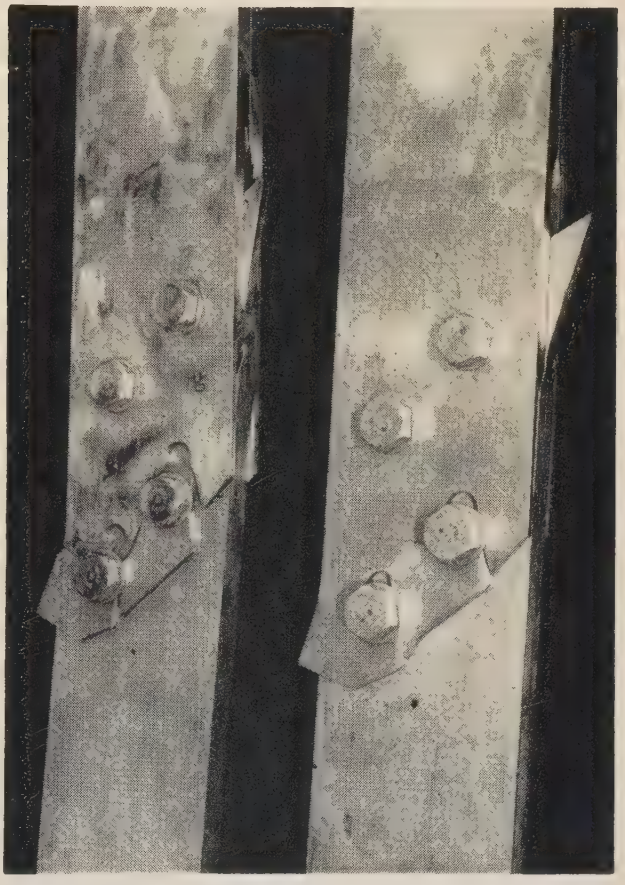

CREEP RUPTURE failures in tests of large bolted joints of forged aluminum alloy at 400 deg F: A brittle failure of 2014-T6 alloy (left) and a ductile failure of 7075-T6 (right). The tests were run by the National Bureau of Standards as part of a research project aimed at finding methods for the prediction of creep effects in built-up structures.

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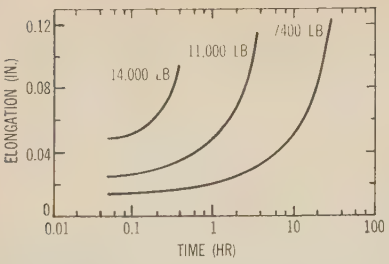

REPRESENTATIVE creep curves obtained at NBS at 800 deg F for three riveted joints of titanium alloys. The tensile loads were kept constant in these tests, which ended at rupture. Equivalent curves may be predicted directly from materials data.

The strength of a joint under static conditions normally is figured from the ultimate tensile, shear, and bearing strengths of the materials involved. The loads needed to produce the various modes of failure are compared, and the strength of the joint is taken to be the smallest of these.

In creep loading, just as in loading at room temperature, a riveted joint may fail by tension, bearing, or shearing. However, creep rupture strength decreases both with temperature and with the time during which a joint is at a given temperature. Once these variables are specified, you can calculate loads that will produce the various modes of failure.[1]

The creep rupture strengths of materials often are known for tension loadings only. The creep rupture properties can then be estimated in terms of efficiency: the ratio of joint strength to the unriveted-sheet strength of the same material. The assumption that this ratio is the same under creep conditions as under normal static conditions implies that the variation of bearings and shear strengths with temperature and time is similar to the variation of the tensile strength. The creep rupture strength of a joint therefore is the tensile creep rupture strength of the sheet material multipled by the joint efficiency.[2]

For many structures (e.g., airplane wings), joints that don't rupture within the specified lifetime are not sufficient. If aerodynamic contours are to be preserved, the joints must also be proof against excessive deformation.

Designing for allowable deformation is made easy by the stress-sensitive nature of creep; relatively large changes in deformation rate result from small changes in stress. Thus creep deformations due to the individual stresses—tensile, bearing, and shear—often differ by as much as an order of magnitude in a given joint. Deformation or elongation therefore usually can be attributed to the stress producing the largest deformation and finally rupture.

For example, a joint calculated to rupture under bearing may be considered to creep only in that type of loading. The elongation then is the same as that for a bearing specimen under the same stress and temperature.

(1) L. Mordfin & A. C. Legate, "Creep Behavior of Structural Joints for Aircraft Materials under Constant Loads and Temperatures;" NACA TN 3842 ('57).

(2) Mordfin, G. E. Greene, N. Halsey, R. H. Harwell, Jr., & R. L. Bloss, "Creep and Static Strengths of Large Bolted Joints of Forged Aluminum Alloys under Various Temperature Conditions;" IAS Preprint 779 ('58).

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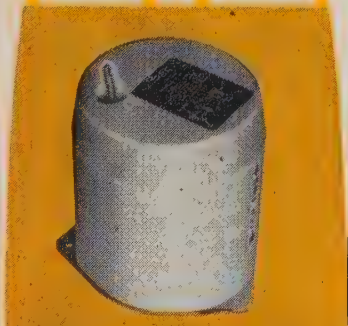

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n many applications, joints are jected to varying loads and tem- atures. To calculate the time to ture or the time to reach the wable deformation in such a e, you divide the history of the t into small increments of time, ing which load and temperature y be taken as constant. The tion of life expended during h increment then is that incre- nt divided by the total life ex- ted under the constant load and perature. When the creep be- ior in any increment isn't af- ed by the conditions in earlier rements, rupture or the allow- e deformation is reached when sum of the life fractions reaches y.

ep generally depends on t history

his holds true, however, only n the material is metallurgically le and load and temperature nges are not severe. Generally, p *is* a function of past history, the limiting condition is hed when the sum of the life tions equals the so-called "time-ratio", which is some quantity other than unity. The best way of figuring the time ratio for a joint is to base it on the behavior of the joint material: the time ratio for a joint may be considered equal to the time ratio for rupture of the joint material under the same conditions.[3]

A material specimen that has undergone a certain amount of creep might be expected to yield more quickly to momentary periods of overload than would a "new" specimen. NBS found, however, that moderate amounts of creep usually cause only a small change in tensile properties and sometimes even a beneficial one. Riveted joints have shown the same behavior, NBS reports. In fact, for design purposes that strength reduction of a joint caused by prior creep can be considered equal in percentage to the reduction observed for the material from which the joint is made.

The strength of a joint that must

(3) Mordfin, Halsey & Greene, "Investigations of the Creep Behavior of Structural Joints under Cyclic Loads and Temperatures;" NASA TN D-181 ('59).

more on next page

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MA — **MONROVIA AVIATION:** Producers of precision aircraft structural assemblies, Monrovia Aviation's products are installed on America's principal military and commercial jet aircraft. This Subsidiary also designs and manufactures customized portable air conditioning units for missile ground support purposes.

TS — **TELECOMPUTING SERVICES:** Skilled in the establishment and operation of data processing centers, primarily for military and civil agencies of the Government. At White Sands Missile Range, TSI processes and analyzes missile test data. At Vandenberg AFB, this Subsidiary provides data processing services for SAC's 1st Missile Division.

ES — **ELECTRONIC SYSTEMS:** Specialists in systems management, this Division also designs and manufactures a wide variety of equipment in the fields of electronics and nucleonics for highly classified Military Programs. In addition, Electronic Systems designs and produces Air Traffic Control equipment for the Federal Aviation Agency.

DI — **DATA INSTRUMENTS:** Leading designer and producer of data reduction systems for ground support and range instrumentations. Product line includes shaft rotation digital equipment, decommutators, and other highly complex and specialized instruments for missile and aircraft testing, telemetering and in-flight operation.

EC — **ELECTRONIC COMPONENTS:** Designs and produces components, including magnetic amplifiers, transformers, micro-miniature relays, delay lines and high temperature ceramic capacitors. These reliable components are being selected for installation in many of the country's principal missile and space programs.

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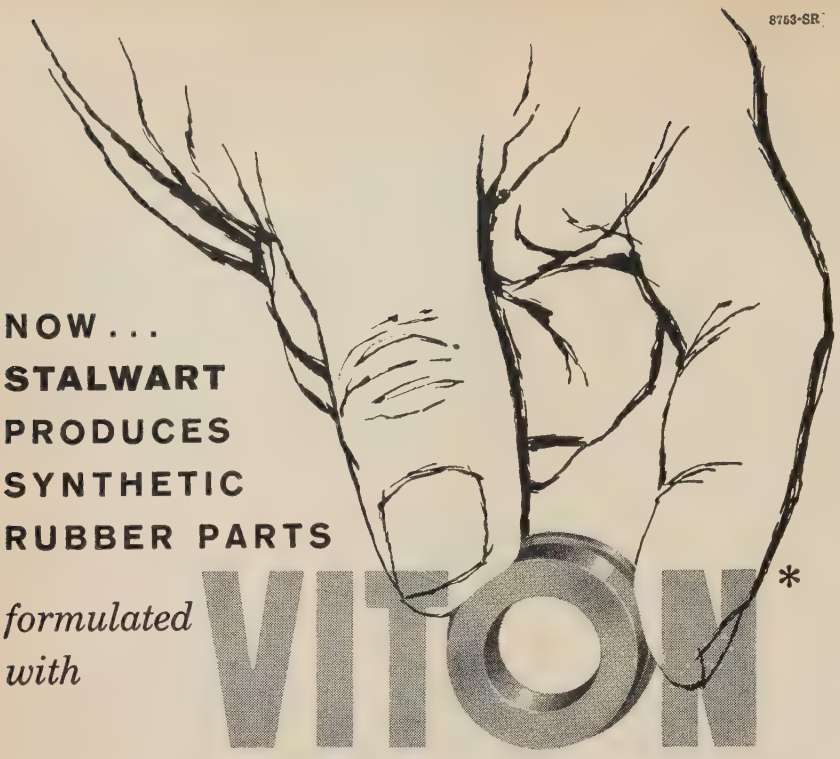

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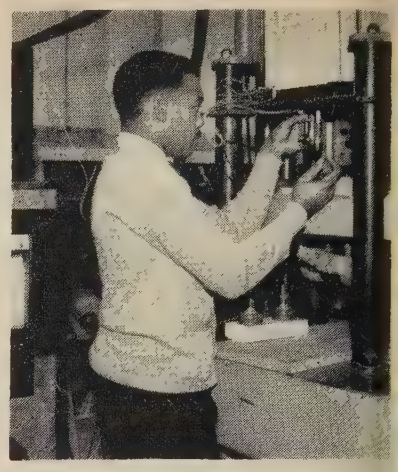
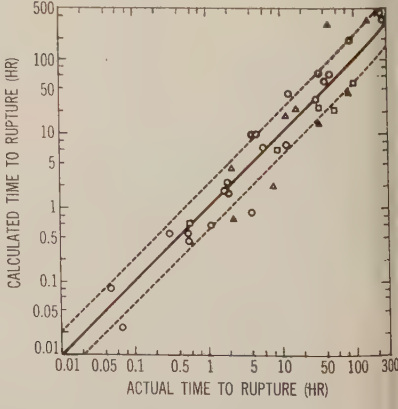


CREEP TESTING of joints at NBS. Specimen under load is in a furnace kept at creep-producing temperatures. A differential transformer is being mounted on the extensometer rods below the furnace to transmit time-dependent deformation of recording equipment at upper left.

have a specified lifetime under given temperature conditions can be found within 10 per cent with its methods, NBS says. On the other hand, in calculating the lifetime for a given load and temperature condition, errors may be as high as 2:1—a result of the stress-sensitive nature of creep, which causes small changes in stress to lead to large changes in lifetime.—End

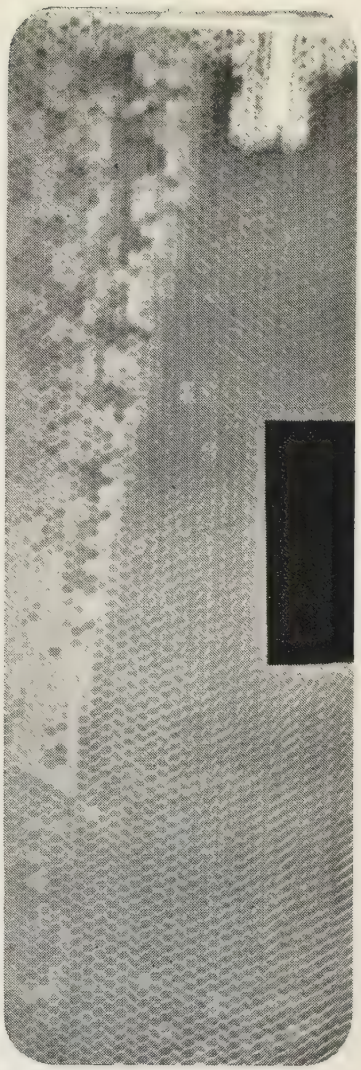
CALCULATED times to rupture for riveted aluminum alloy joints are compared with experimental times. Rupture occurred at 300, 400, and 500 deg F because of tearing of sheet (circles), shearing of sheet (triangles), or shearing of fasteners (squares). Points on the solid line show zero discrepancy between calculated and actual times to rupture; those on the broken lines show a 2:1 discrepancy.



Technician of New York Testing Laboratories places Kodak Industrial X-ray Film, Type AA, in position.

Keeping tab on trim tabs

Rigid inspection of American Airlines' jets includes radiography of trim tabs to reveal any accumulation of water from condensation.



Radiograph shows area where condensate is entrapped in honeycomb.

At the altitude and speeds which jet aircraft fly, temperature changes are frequent. This often means condensation—sometimes water accumulation in the honeycomb construction of the trim tabs.

This is something American Airlines keeps track of in its periodic rigid inspections. Best way is by radiography. And New York Testing Laboratories was one company given the assignment.

With a mobile X-ray unit, and using Kodak Industrial X-ray Film, Type AA, the inspection is made quickly and a lasting record obtained.

In such inspections of assemblies, in quality control, nondestructive testing, radiography provides a means of determining internal conditions.

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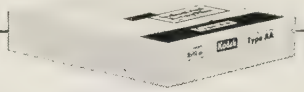

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Here is Francis Alterman, Manager of General Mills Digital Computer Laboratory, checking one of our newest computers which he helped design. General Mills computers, both analog and digital, are being used in missile guidance, bombing and navigation systems, automatic surveying and in industrial control. In future space travel, computers will help control navigational systems of space vehicles and will process data gathered in outer space.

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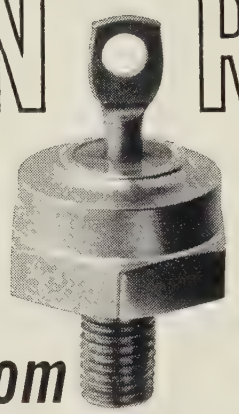

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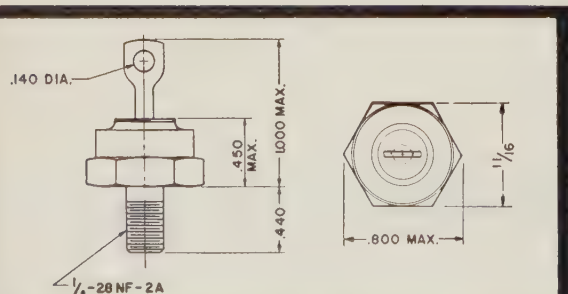

TYPE	AVG. DC CURRENT	PIV	NORMAL MAX. TEMP.	MAX. FORWARD DROP	MAX. REVERSE CURRENT
1N1191A	22A	50V	150°C	1.2V at 60 amps.	5.0 MA
1N1192A	22A	100V	150°C	1.2V at 60 amps.	5.0 MA
1N1193A	22A	150V	150°C	1.2V at 60 amps.	5.0 MA
1N1194A	22A	200V	150°C	1.2V at 60 amps.	5.0 MA
1N1183A	40A	50V	150°C	1.1V at 100 amps.	5.0 MA
1N1184A	40A	100V	150°C	1.1V at 100 amps.	5.0 MA
1N1185A	40A	150V	150°C	1.1V at 100 amps.	5.0 MA
1N1186A	40A	200V	150°C	1.1V at 100 amps.	5.0 MA at 150° C case temperature and rated PIV

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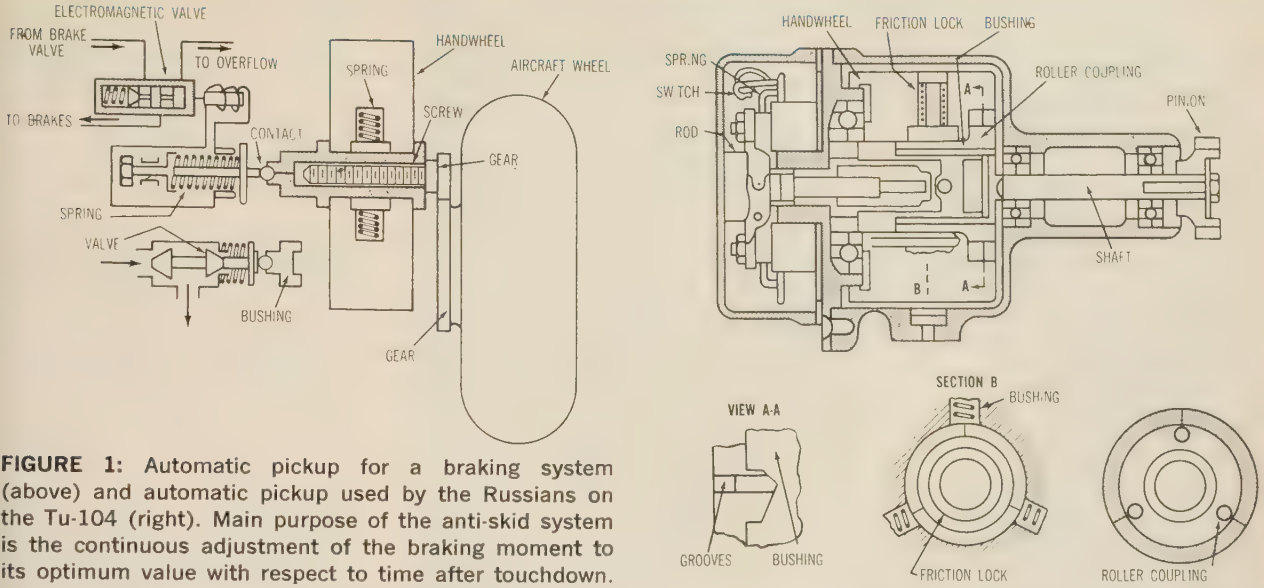

FIGURE 1: Automatic pickup for a braking system (above) and automatic pickup used by the Russians on the Tu-104 (right). Main purpose of the anti-skid system is the continuous adjustment of the braking moment to its optimum value with respect to time after touchdown.

Anti-skid braking

of Russia's Tu-104 jetliner

What does detail design look like in the Soviet aerospace industry? A partial answer at least is given in this extensive description of the braking system used on the Tu-104 twin-jet transport, which is reported to have a maximum gross weight of 164,250 lb.

by T. M. Bashta, Head, Dept. of Aeromechanics & Aircraft Design, Kiev Institute GVF*

IN BRAKING an aircraft, the moment of friction forces on the brake lining (M_t) and the moment of the contact force between tires and ground (M_{sts}) becomes effective. No skidding will occur so long as M_t does not exceed M_{sts}.

For all practical purposes, M_t depends on the pressure in the brakes—the higher the pressure, the greater the braking moment. M_{sts} is influenced by the vertical load on the wheel, the rolling speed of the tires, the condition of the runway surface, the type and condition of the tread, etc. Basically we can say that M_{sts} depends on two parameters: the vertical load on the wheel and the adhesive capacity factor. These in turn are greatly influenced by the nature of the landing (*Fig. 2*).

The braking moment, or fluid pressure in the brakes, corresponding to the tire's contact with the ground before the wheel begins to skid can be shown to increase with time after touchdown. If during landing the braking moment is continuously adjusted to this value, the landing run is reduced to a minimum. For such adjustment, an automatic system is best.

Figure 2 shows such a system.

more on next page

* This is a condensation of a translation taken from "Selected Articles by Various Authors from *Grazhdanskaya Aviatsiya*, No. 11, November 1956," prepared by Liaison Office, Technical Information Center, MCL-TD, Wright-Patterson AFB, Ohio.

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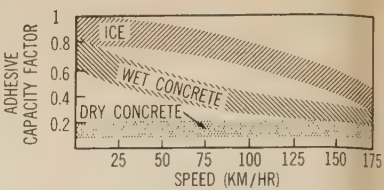


FIGURE 2: Adhesive capacity factor upon tire contact with the ground.

It eliminates the inconsistency of angular speed between the airplane wheel and the mechanically connected handwheel. The latter is mounted on a bushing carrying a nut for the screw linked to the wheel over two gears.

A friction lock connects the handwheel to the hub. The strength of the connection is regulated by a spring. Until the handwheel slips on the friction bushings, this assembly can be considered a single, integral part turning on a screw.

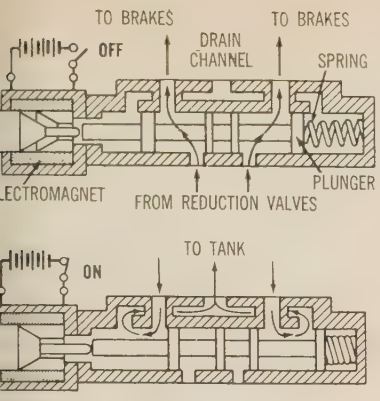
Handwheel is synchronized with aircraft wheel

When the wheel unwinds, the screw shifts the handwheel to the extreme right position. The handwheel now is synchronized with the aircraft wheel, but only after a large number of turns, after which braking occurs.

As angular deceleration of the aircraft wheel occurs because of partial or full seizing, the angular speeds of the wheel and the handwheel become unstable. The handwheel is displaced together with bushing and screw and shifts to the left, depressing an electric contact. This action triggers an electromagnetic valve that releases the wheel.

Another valve is mechanically connected to the bushing and is thrown to the left position. It overlaps the supply line and connects the brake line with the drain line. The handwheel on reaching the extreme left position stops moving to the bottom of the screw. It continues, however, to turn on its axis slipping on the brake shoe and continuing the electric contact of the valve in the left position, corresponding to the "braking" condition.

By turning the wheel, the inconsistency of the angular speed is eliminated. The speed of the aircraft wheel will be higher than that of the handwheel. The screw turning into the bushing displaces the handwheel to the right and trans



IGURE 3: Electromagnetic valve sed in the Tu-104 braking system.

its it to the angular speed of the ircraft wheel. The handwheel tops depressing the electric con- act or the valve, letting the fluid reach the brakes under pressure gain.

The sensitivity of the system de- ends on the springs. The greater ie pressure, the greater should be ie deceleration of the wheel, so iat the handwheel can trigger the lectric contact or the valve. The prings control the minimum fric- on moment of the lock. The maxi- ium valve of this moment is lim- ed by the fact that the handwheel, a given free force, should not op moving until the braking and idding stop.

A similar system is used on the u-104 (*Fig. 2*). An inertia hand- heel is connected to a bushing by roller coupling and friction locks. he bushing is mounted on the left id of a shaft with two longitudinal rooves engaging guiding lugs from pusher. The lugs on the pusher e held against the diametrically ranged cam grooves of the bush- g with profiled ends.

ne handwheel overshoots the rcraft wheel

If the aircraft wheel decelerates cause of wedging, the handwheel ershoots the aircraft wheel, en- aining the bushing through the iction drive, and forces the pusher the left by means of cam bevels. he pusher triggers two electric witches and releases the wheels. this way, the inconsistency in gular speed is eliminated, and the g of the pusher enters the cam ove of the bushing. Under spring tion, pusher and rod shift to the right. The released electric switches then actuate the electro-magnetic valve to brake the wheel.

The system is connected with the aircraft wheel gear by a pinion. The transmitting valve of this connection is so designed that, for a landing speed of 200 km/hr, the handwheel turns at about 10,000 rpm.

To prevent irreversible full seizing a brake release and two cam rods are used. One of the rods releases the wheel brake when the wheel seizes, the other prevents braking up to the moment when the unwinding aircraft wheel and handwheel have developed the proper speeds. The shaft connected to the wheel is turning at a higher acceleration and instantly connects the brakes when it overtakes the bushing. Then a bevel pushes a gear to the left and disconnects it again. Thereafter braking occurs only when the aircraft and handwheel decelerate.

Any pulse acts on pickups of all wheels

The inertia pickup of the braking system is connected with the brake release valves by an electric circuit in such a way that any pulse for releasing the brake that is supplied to the pickup of one wheel will affect all wheels. The release valve is a dual slide-type distributor (*Fig. 3*). Each half controls the wheels of either the right or the left bogie. When the valve's electromagnet is disconnected, hydraulic fluid entering from reduction valves and passing through one set of channels is directed into another connected with the wheel brakes.

When the pickup element of any wheel wears out, the electromagnet counteracts the force of the spring and shifts the plunger into the right position, blocking the first set of channels. The channels normally connected to the wheel brakes are connected with the drain channel instead, and the wheel brakes are released.

In the Tu-104, the pickup element could be installed only on some of the wheels, for in braking the loads are redistributed between the front and rear wheels of the bogie. The load on the front pair is somewhat higher than that on the rear wheel. Since normally the least loaded rear wheels will

more on next page

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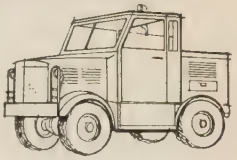
Ground Support Equipment



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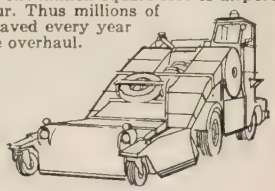

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Automatic multiple circuit analyzers similar to the one shown have been built by Consolidated Avionics for major electronics and missile manufacturers. They search more than 2,000 points in a system and point out wiring errors and doubtful connections. It is one of many highly specialized electronic units produced by Avionics. Other products include data reduction systems and a complete line of transistorized power supplies.

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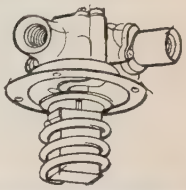

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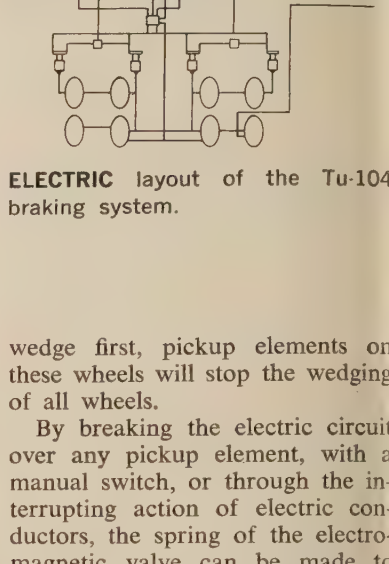


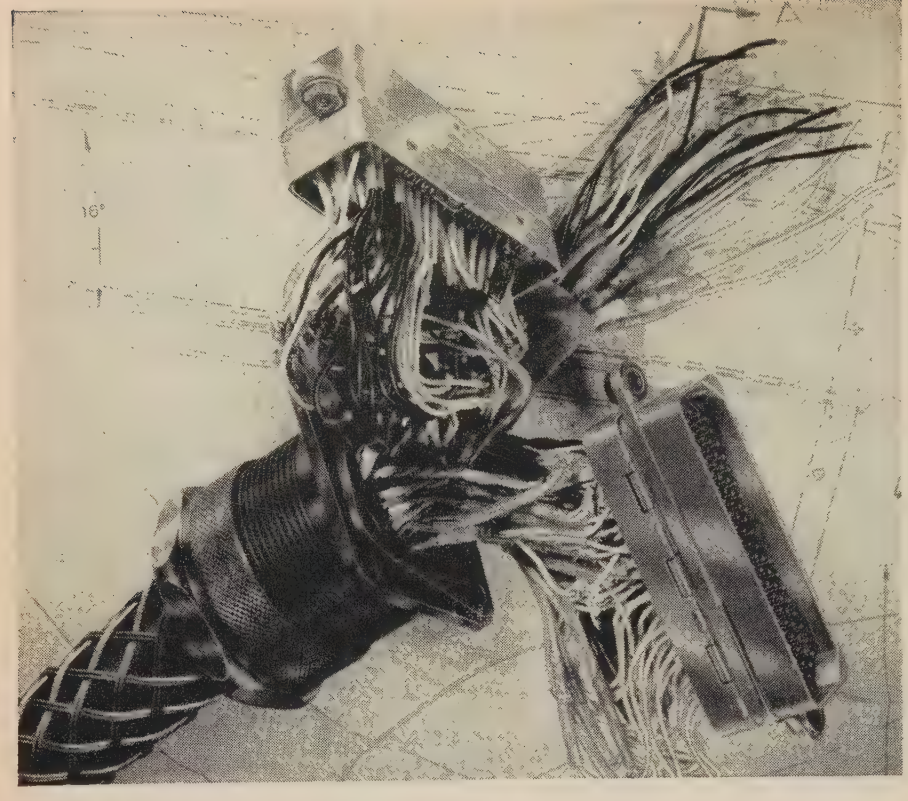
ELECTRIC layout of the Tu-104 braking system.

wedge first, pickup elements on these wheels will stop the wedging of all wheels.

By breaking the electric circuit over any pickup element, with a manual switch, or through the interrupting action of electric conductors, the spring of the electromagnetic valve can be made to shift the plunger to the "braking" position. A hydraulic relay protects the valve electromagnet from overheating in case the switch of any pickup element fails while the circuit is closed. As soon as the reduction valve reduces the pressure (releasing the brake pedal), the relay breaks the conducting circuit of the electromagnet. Emergency brake control is obtained via a separate valve that makes it posible to bypass the automatic system circuit.—End

A CORRECTION

In the table "Altimeters for Low Altitude and Flareout Use", p. 137 of the February 1960 issue of Space Aeronautics the wrong company was given credit for development of the APN-100 radar altimeter. This altimeter (as mentioned on page 134 of the accompanying article) was actually developed by Emerson Radio Phonograph Corp., Government Electronics Div., 1140 East-West Highway, Silver Spring, Md. The APN-100 was developed by Emerson Radio & Phonograph under an Army contract and is currently in the test phase. A modified version especially designed for flareout has also been built by Emerson Radio & Phonograph and will be used with Autonetics' APN-114 landing system in flight tests by USAF and FAA.



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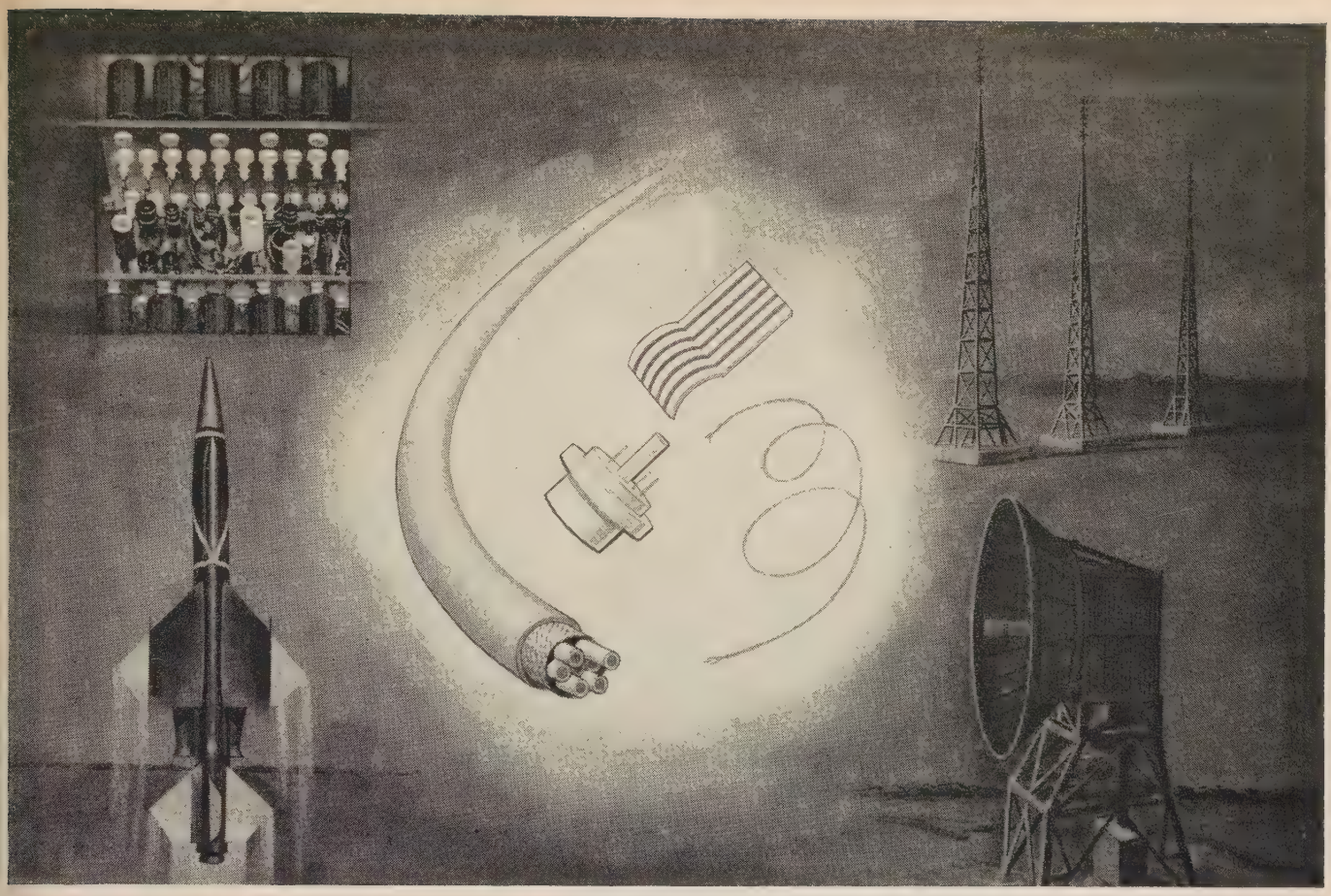

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And because TEFLON FEP-fluorocarbon resin is melt-processible, it can be extruded as jackets for wire and cable . . . as long, continuous lengths of wire insulation . . . and rapidly fabricated into complex shapes.

The new opportunities for improved design offered by TEFLON FEP resin are particularly important in aeronautic and space applications . . . wherever there is a premium on the utmost reliability, simplified assembly, savings in weight and space through miniaturization.

For more information about the properties and applications of TEFLON fluorocarbon resins, including additional data on the characteristics of the new FEP resin, write to us, mentioning your field of interest. Address: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept. T-63, Room 2526, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

DU PONT TEFLON®
FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

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YOUR MACH 3 PROBLEMS

may already be solved at RYAN

At Mach 3—three times the speed of sound—the heat becomes unbearable for conventional airframe metals. The stress becomes too great for conventional methods of fabrication. These are problems which have been overcome by new design concepts and advanced manufacturing techniques at Ryan.

Ryan's intensive research has created unique tools and techniques for the forming of tough-to-handle Space Age alloys . . . and new forms for these alloys to take.

One such technique is explosive-forming. With it, Ryan can form large structures from tough alloys and hold dimensions to tolerances which cannot be achieved by any other methods.

For rocket chambers, Ryan has developed Ryan Wrap, now being tested for the Navy's submarine-launched Polaris missile. Ryan Wrap — spot-welded layers of foil-gauge stainless steel — is lightweight, yet incredibly strong. It will withstand wall stresses of 305,000 pounds psi.

Another significant Ryan development is MiniWate, awarded first prize at the National Design Engineering Show. MiniWate—an extraordinarily strong and heat-resistant spot-welded structure of stainless steel foil and miniature corrugations — can reduce aircraft structure weight by as much as 30 percent.

For hot parts or complete systems . . . for precision quantity or small-unit production . . . for high quality and on-time delivery . . . call on Ryan to do the job.

RYAN OFFERS CHALLENGING OPPORTUNITIES TO ENGINEERS

RYAN BUILDS BETTER

AIRCRAFT · MISSILES & COMPONENTS · ELECTRONICS

Ryan Aeronautical Company, San Diego, Calif.

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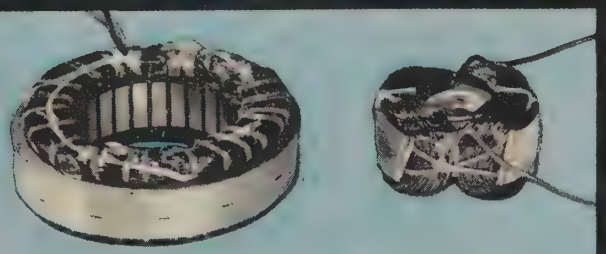
aerospace electronics

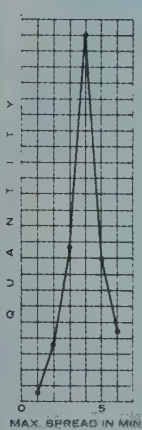
Sensitive radiation detector is a thin slice of doped silicon that emits pulses when charged particles strike it

MARCH 1960

SYNCHROS *for* GYRO PLATFORMS

by cppc





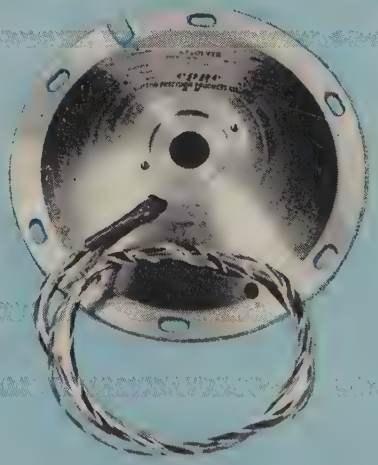
6′ max. error spread Synchro for Gyro Pick-Off

The SG-17- and ST-17- type pancake synchros (SG-18- and ST-18- with housings) are our most standard line for gyro pick-off applications.

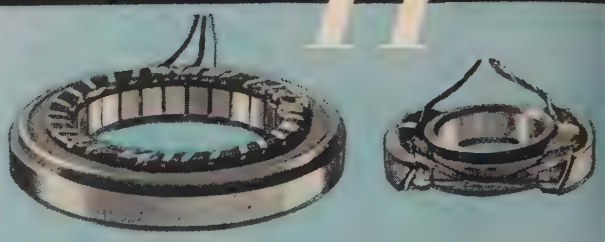
These units have been manufactured in large quantity and are readily available for prototype breadboarding. The high accuracies shown on the left are obtainable in standard 26v or 115v units.

Pancake Resolver for Gimbal Mounting

Clifton Precision produces special pancake resolvers for direct gimbal mounting. They were developed for use in cascaded amplifierless resolver systems and have been trimmed for 10K input impedance, 0° phase shift and a constant transformation ratio, with temperature, at 900cy. Accuracies of 4′, perpendicularities of 3′ and nulls of 1mv/v of output or less can be held.



Special techniques maintain concentricity between rotor and stator — thus reducing difficulties commonly encountered in gimbal mountings.

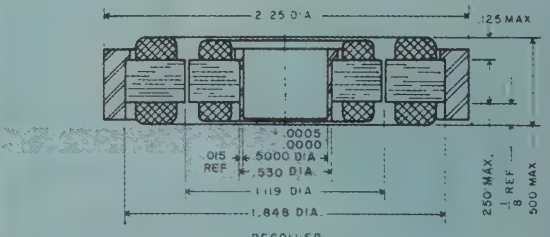


Custom Designed Pancakes

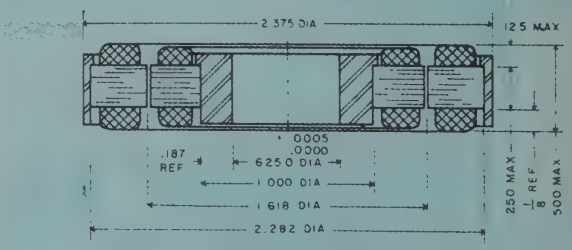
CPPC has developed a number of special pancakes (drawings below) with relatively large bores and narrow stack heights.

Means have been devised to minimize error due to clamping pressures on these thin units.

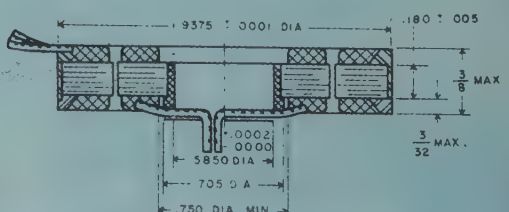
Special accuracies have been maintained where required. Let us know your needs.



RESOLVER



TRANSMITTER OR RESOLVER



TRANSMITTER

ENGINEERS — Join the leader in the rotating components field. Write David D. Brown, Director of Personnel, Dept. J7

cppc CLIFTON PRECISION PRODUCTS Co., INC.

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GE's cryogenic research in new lab covers five areas

CRYOGENIC RESEARCH work was disclosed by General Electric at the recent formal opening of its new cryogenic lab. GE announced it was probing into these basic cryogenic phenomena:

- *Superconductivity*—Some 20 pure metals and many alloys and compounds have no electric resistance at temperatures within a few degrees of absolute zero.
- *Magnetic Flux Trapping*—Currents can be trapped in superconductive coils, creating a constant magnetic field that lasts indefinitely.
- *Magnetic "Insulation"* — Superconductors will act as "insulators" to magnetic lines of force. Up to a certain strength, a magnetic field cannot penetrate a superconductor. Instead it induces permanent counter-currents on the superconductive surface. These currents repel the first field.
- *Critical Field Strength*—In a magnetic field of a certain (critical) strength, a superconductor becomes resistive. The critical point varies with the type of material and the temperature in the cryogenic range.
- *High Frequency Behavior* — Cryogenic researchers theorize that superconductors have "super-electrons" that avoid collision with the crystal lattice. In addition, superconductors have normal electrons, which can collide under ac conditions. This theory explains the fact that while there is some resistance to ac currents in superconductors (noticeable above 10 mc), surface resistance is still far lower than even that of copper or silver at low temperatures.

Seven electronic applications listed for cryogenics

POSSIBLE USES of cryogenic phenomena were listed by GE researchers as:

- The *shaping of magnetic fields* to construct extremely high resolution magnetic lenses;
- *current standards* made by circulating currents "frozen" in superconductive coils;
- *frictionless bearings* using a superconductor suspended in space by a "frozen-in" flux;
- *high efficiency motors* consisting of a cylindrical or spherical cryogenic body turned by a rotating flux and with acclaimed efficiency (ignoring power supply losses) approaching 100 per cent;
- *gyroscopes* using a frictionless bearing rotor turned by a rotating flux;
- *dc-to-ac amplifiers* with no zero drift and no noise (the dc input current would be fed into a lossless superconductive control winding; flux from this winding would be chopped by a rotating superconductive disk consisting of segments acting as magnetic insulation; a second winding would produce an ac voltage and output power);
- *cryotron* switches for computers (see AVIATION AGE, *"Cryogenic Electronics," March '58, p. 174*);
- *very-high-Q cavities* (with Qs measured in millions) taking advantage of the small surface resistance of superconductors at high frequencies for use in frequency standards with claimed accuracies approaching those of atomic clocks.

Great accuracy improvement is forecast for a cryogenic gyro by GE

CRYOGENIC GYRO is under development at GE's new lab. Sponsored by the Army Ballistic Missile Agency, "Project Spin" has already produced and successfully tested a cryogenic motor and bearings for the gyro. It will use a golf-ball sized spherical rotor spinning at 20,000 rpm inside a high vacuum.

The cryogenic gyro, predicts GE, will be many times more accurate than the best current conventional gyros now available. The elimination of mechanical bearings, reduction of friction and electric losses "almost to zero," and heightened dimensional stability induced by the extremely low temperatures would produce the increase in accuracy.

COMPLEX PLUMBING seems to be the biggest drawback of a gyro working at liquid helium temperatures. Even assuming a super-accurate "cryo-

more on next page

Cover Story—Tiny solid-state ionization chamber developed by Hughes Aircraft could be both a valuable tool for studying radiation belts in space and a means of detecting the operations of nuclear-powered vehicles.

gyro" can be built, without cryostats (helium liquefiers) in small, lightweight packages, the gain in precision might not be worth the penalties in size, weight, and complexity.

MOLECULAR ELECTRONICS "progress report" was given by Wright Air Development Division (WADD) and Westinghouse Electric. The company has been working on a $2 million ARDC contract to "demonstrate the feasibility of inherently reliable electronic equipment requiring greatly reduced amounts of power and taking up very little space."

Westinghouse is working on the basis of its dendritic-growth technique, in which semiconductor crystals are grown in long thin, nearly perfect ribbons. Multi-zone crystals grown in this way form the building blocks of Westinghouse's molecular systems.

Functional molecular blocks demonstrated by Westinghouse included:

- an *audio amplifier* with up to five watts output and zero to 20 kc frequency range;
- a *dc amplifier* with four milliamperes input and 40 W output;
- a *video amplifier* with a flat response out to several megacycles;
- *a tuned amplifier* with a semiconductor notch filter;
- *multivibrators* of bistable, monostable, and astable design;
- *"or"* and *"and"* switches;
- *variable potentiometers* with no moving parts (consisting of a molecular-electronic functional block that generates a signal in proportion to two dependent input signals).

Completely molecularized receiver is predicted for next year by USAF official

BOUQUETS were heaped on Westinghouse by WADD. Col. W. S. Heavner, chief of WADD's Electronic Technology Lab, said: "I think this is one time the Air Force has had a very remarkable return for its money."

According to Heavner, WADD wants Westinghouse to produce a complete molecularized receiver by '61. "We need a gimmick to show the public what we are doing," he said. Operational molecular electronic equipment is expected by USAF in 3-5 years, Heavner told SPACE/AERONAUTICS.

HEAVNER WARNED that the idea of electronic equipment made of assembled components is fast becoming passé. He told electronic suppliers that "for low power applications, USAF does not intend to use components now or in the future. If electronic component makers want to get on the bandwagon, they better get into molecular electronics." Speaking to the aerospace industry at large, Heavner said USAF has its doors open to all companies and all ideas on molecular electronics.

MOTOROLA, RCA, and Texas Instruments are other companies doing molecular electronics work, said Heavner. He noted that RCA's integrated concept is not what USAF defines as a molecular approach but that recently RCA has come around to accept the molecular philosophy. Heavner predicted that Motorola would soon make a big announcement of its molecular electronics work.

Texas Instruments has a WADD contract to build a molecular electronic computer, according to semi-official sources at the WADD-Westinghouse conference.

Semiconductors are best for molecular blocks right now

WESTINGHOUSE pointed out that molecular electronics is not restricted to semiconductors. Right now, it said, semiconductors appear to have the best properties for molecular blocks. The company is looking for other suitable materials that will live in military environments.

THERMOELECTRIC GENERATORS are likely to be used as power sources for molecular-electronic functional units, a Westinghouse spokesman said.

•

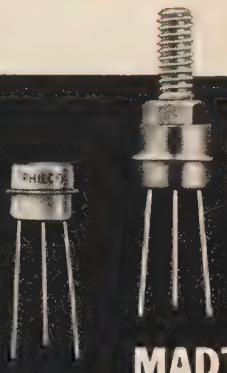
HOW GOOD is Soviet ICBM guidance? If we are to believe the Reds, their first ballistic missile shot 7762 miles into the Central Pacific Ocean landed within 1.25 miles of its target point. (A second Soviet ICBM was shot into the same area early last month, but no performance figures were given.)

The Reds are believed to be using radio-type guidance (a beam rider, according to some sources; a radio-Doppler type, according to others). Because the tracker has to see a radio-guided ICBM all the way during the guided phase,

more on page 118

HILCO ANNOUNCES

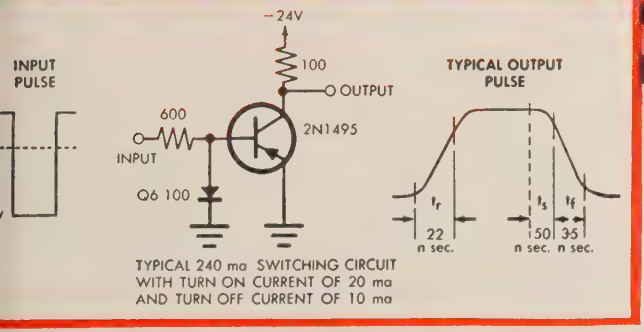
HE FASTEST HIGH-CURRENT WITCHING TRANSISTORS!



MADT*

2N1495 • 2N1496
2N1204 • 2N1494

These Diffused-base Transistors are capable of utilizing the full speed of new magnetic film memory planes



TYPICAL 240 ma SWITCHING CIRCUIT WITH TURN ON CURRENT OF 20 ma AND TURN OFF CURRENT OF 10 ma

These new Philco MADTs are the result of a revolutionary new development of the Precision-Etch process, which gives high switching speed at high currents. *They are capable of switching 400 milliamperes of current at a 10 mc clock-rate* . . . and are the only transistors available today that permit full utilization of high-speed magnetic film memory planes. The typical f_T of 120 mc at 100 ma makes these units particularly suitable for video drivers, pulse line drivers and other high-current switching circuits. The ultra high-frequency response at the levels normally encountered in current-switching logic circuits, coupled with high dissipation capabilities, makes these units desirable for this class of circuit application.

Both the 2N1495 and 2N1204 are available in studded versions for higher power applications. Typical characteristics are shown in the accompanying table. For complete application data, write Dept. SA-360.

*Reg. U. S. Pat. Off.

TYPICAL CHARACTERISTICS

	CASE	P_T @25°amb. (Max)	V_{CES} (Max)	$V_{CE(SAT)}$ $I_C=-200ma$ $I_B=-10ma$	V_{BE} $I_C=-200ma$ $I_B=-10ma$	h_{FE} $V_{CE}=-1v$ $I_C=-200ma$	f_T $V_{CE}=-10v$ $I_E=25ma$
95	TO-9	250mw	−30v	0.35v	0.60v	60	320mc
96	TO-31	*0.5w	−30v	0.35v	0.60v	60	320mc
04	TO-9	250mw	−20v	0.35v	0.60v	60	320mc
94	TO-31	*0.5w	−20v	0.35v	0.60v	60	320mc

case temp.

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the missile normally follows a higher-angle trajectory than an inertially guided ICBM. Guidance experts say it is easier to get high accuracies with a high-angle trajectory. They claim that, for guidance accuracy, a high trajectory angle is about three times better than the optimum angle. Of course, the drawbacks of a high angle trajectory are that it requires more thrust and fuel, and that exposes the ICBM to earlier detection.

ICBM guidance controversy will soon be resolved

DESPITE the apparent advantages of inertial guidance for ICBMs, many in the industry are still trying to convince the Air Force that the inertial art is still not capable of producing guidance systems of ICBM accuracy. These dissenters claim USAF will eventually have to use radio guidance for all of its Atlas and Titan missiles.

The reply of the inertial people is "sour grapes". By the end of the year, we ought to know who's right.

•

"SAGE" for the zone of exterior, formally known as Project 412L, is slated for the defense of Alaska and certain parts of Europe. The system made by GE's Heavy Military Electronics Dept. under contract from Rome Air Development Center (RADC) will control any of the weapons expected to be in our inventory over the next decade. It will also tie into the Nike-Zeus system.

KEYSTONE OF 412L is believed to be an ultrafast, versatile digital computer programed by magnetic tape. Tapes can be substituted to program the computer for different weapons, says RADC.

PENTAGON COMMAND POST will be automatized under Project 473L, soon to be awarded by RADC. The project will enable the command post (now manually operated) to accept data furnished by automatic systems and process it digitally.

RADC estimates the new system will result in a 1500-2500 per cent improvement. An RADC spokesman told SPACE/AERONAUTICS that information will be simultaneously displayed to "all cognizant officers" in less than one minute of receipt.

PINCUSHION RADAR, being made by Raytheon for testing in the Central Pacific possibly to observe the Russian Ballistic missile launchings) was originally conceived by RADC scientists Harry Davis and Ira Smith. (Formerly scientific director at RADC, Davis is now special assistant for air defense in DOD's office of Research & Engineering.) One of the important features of the Pincushion concept is that it gives a VHF microwave system the receiving aperture of an LF antenna.

In Pincushion, many narrow beams are radiated from an antenna (by using phased arrays, for example, or Cassegranian-type optics). Separate transmitters can be used for each beam, so each beam can be on a different RF frequency. Obvious advantages of this technique are that:

- very narrow beams can be resolved;
- power can be split over several transmitters;
- jamming is made difficult since the beams can be on different frequencies;
- angular accuracy is high;
- it can be adapted to the needs of electronic scanning and tracking.

Thin slice of doped silicon is used as radiation detector by Hughes designers

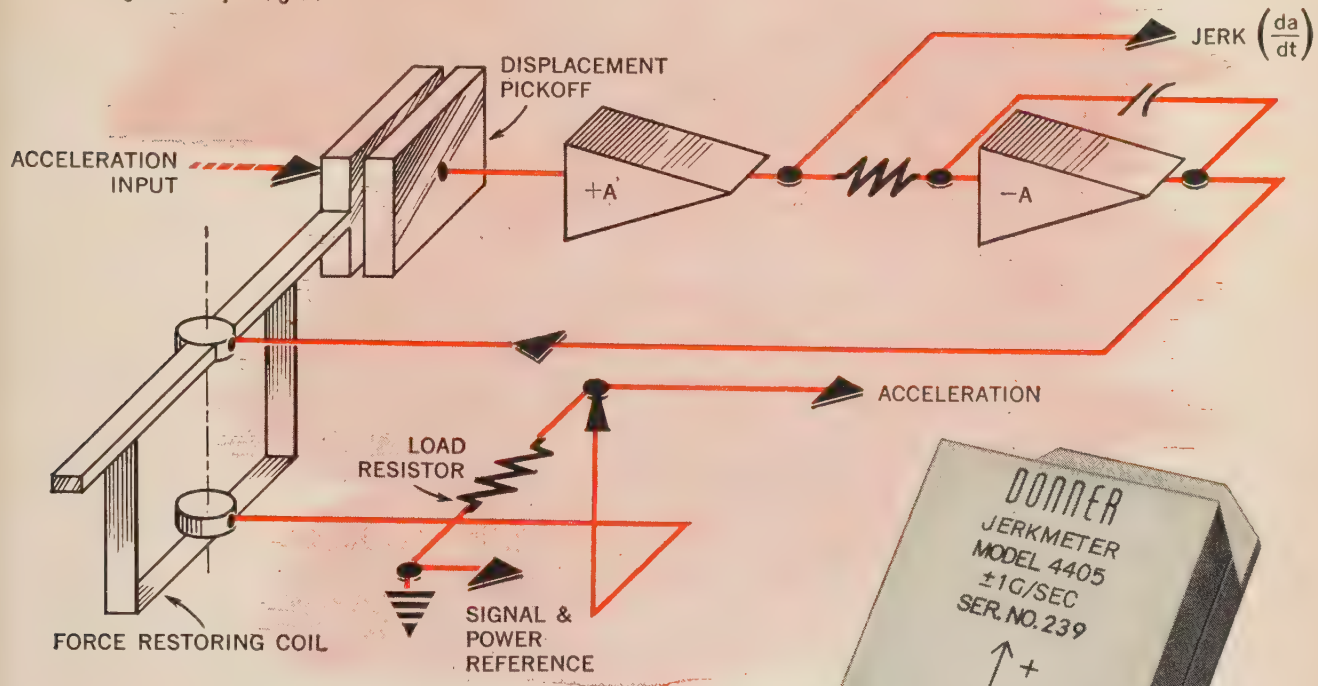
A TINY "solid-state ionization chamber" developed at Hughes Aircraft could prove important for military and space applications, as well as in basic nuclear research. "Smaller than the head of a pin," says Hughes radiation physics chief Dr. Stephen S. Friedland, "the basic device is actually a radiation detector that measures the number and energy of atomic particles traveling at speeds faster than man can comprehend. It lets us make measurements that couldn't be made up to now and performs with far greater effectiveness than existing detectors."

THE HUGHES DETECTOR, which costs only about $20-30, is basically a very thin slice of doped silicon. Struck by a charged nuclear particle, it emits a pulse that can be measured and analyzed. It can make energy measurements with less than 0.5 per cent error, says Friedland.

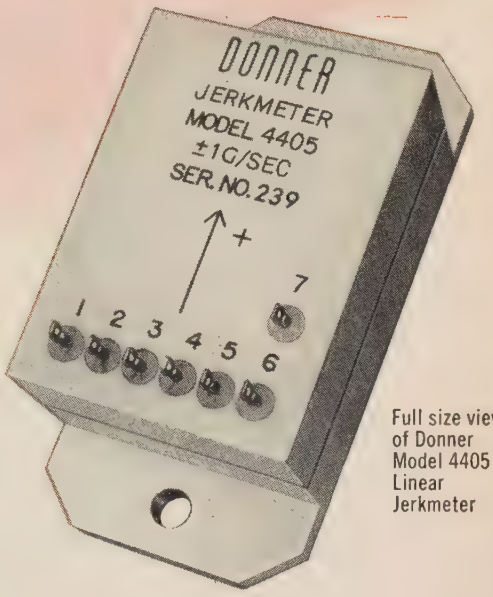
At present, Friedland notes, we use photographic plates in the nose cones of missiles to measure the speed, direction, nature, and energy of cosmic and other outer-space radiation. Rays and particles penetrate the film and define their courses through the layers. The trouble with this technique, Friedland explains, is that you've got to recover the nose cone and then must spend

more on page 120

Functional diagram of Donner Linear Jerkmeter. This unique instrument operates as a subminiature servo-system of the force-balance type which is responsive to jerk along the sensitivity axis of the linear unit and about the sensitive axis of the angular unit. Basically, the system consists of a transistorized accelerometer with an integrator inserted into the servo-loop to generate a jerk signal.



HOW TO MEASURE $\frac{da}{dt}$



Full size view of Donner Model 4405 Linear Jerkmeter

New Donner precision Jerkmeters measure linear and angular jerk to ±0.5% or better.

If your measurement and control problem requires accurate measurement of jerk or the rate of change of acceleration, Donner Scientific's new line of precision angular and linear jerkmeters can help.

These new instruments are the only truly accurate device of this type ever made. They are designed to meet the most demanding applications. Both angular and linear jerkmeters provide an output voltage proportional to jerk which in turn can be used to instigate compensatory control forces or other actions. *An acceleration analog output voltage is also available.*

Typically, a jerkmeter installed in a jet aircraft will provide an instantaneous output proportional to the rate of change of g's. This signal can be used to predict impending disaster conditions.

Other applications include use wherever constant acceleration is required. Here, the Donner jerkmeter provides a "velocity-damping" term. The jerkmeter also provides a third order term for stabilizing displacement devices. It can also be used as an inertial indicator of first motion.

KEY SPECIFICATIONS for Model 4405 Linear Jerkmeter

RANGES
Acceleration: ±1 g full range to ±30 g full range
Jerk: ±0.5 g/sec full range to ±20 g/sec full range

OUTPUT FULL SCALE
Accelerometer: ±7.5 v dc
Jerk: ±7.5 v dc

RESOLUTION
0.1% full scale or better

LINEARITY
0.1% full scale or better

HYSTERESIS
Less than 0.1%

POWER
+15 v dc at 10 ma and −15v dc at 10 ma

SIZE
3" long, 1½" wide, 1⅝" high

WEIGHT
7.5 ounces

WANT MORE INFORMATION? *The new Donner Jerkmeter is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Complete technical information can be obtained by calling your nearby Donner engineering sales representative or writing Dept. 09-3*

DONNER SCIENTIFIC COMPANY
CONCORD, CALIFORNIA

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much time trying to extract the data from the plates.

A THREE-DIMENSIONAL nose cone package containing thousands of solid-state ionization-chamber detectors coupled with an amplifier and telemetering devices would give scientists on earth immediate radiation measurements, Friedland claims. He adds that the new detectors are already being used for basic research purposes.

The military applications of the Hughes device include detection and control developments that are still classified. Obviously they could involve nuclear vehicles and methods of detecting their flight.

X-rays under study for communications use in space

COMMUNICATIONS IN SPACE via X-ray transmission are being studied at Tracerlab under an RADC contract. Though apparently overlooked until now, X-rays have properties that make them well suited for communications across vast spatial distances. Tracerlab engineers believe this type of radiation of intelligence will supplement conventional RF communications systems.

Under the RADC contract, Tracerlab will make theoretical analyses and lab studies leading to a feasibility test aboard a space probe or satellite.

•

MINUTEMAN GUIDANCE system is being tested on one of the fastest liquid-powered rocket sleds ever used, reports Aerojet-General. Project engineers H. M. Poland and J. C. Guidero of Aerojet's Systems Division explain that the Mach 2 sled runs are each programed to represent one or more phases of the missile's trajectory. The purpose of the test series is to prove the environmental stability of the guidance system and to calibrate its velocity meters. The sled is designed for the study of more than one guidance parameter at a time.

REPEATED SLED RUNS let you modify the system until it reaches mission readiness, Poland and Guidero note. The multi-chambered sled provides for in-flight shutdown, so that thrust can be varied. The economy and relibility of this type of testing, the Aerojet engineers add, are important in testing guidance systems, since the tests may require many runs. And the greater the number of runs, the more chance for gyro drift to affect the accuracy of the measurements.

A TRANSISTORIZED atomic-energy gage developed by NAA's Atomics International Div. reportedly measures the amount of fuel in aircraft and missiles more accurately and reliably than conventional devices. The lightweight, radiation-sensitive device was checked out in a jet bomber at altitudes up to 38,000 ft. Cosmic radiation or changes in altitude had no effect on the gage's performance, say AI engineers.

USABLE WITH all types of solid and liquid fuels, the gage system consists of gamma-radiation sources like cobalt 60, scintillation detectors containing a ratemeter and a pulse amplifier, a power supply, and an indicator. Radiation sources and detectors are mounted on the sides of each fuel tank. Gamma rays given off by the radioactive materials decrease in intensity as they pass through the fuel. The amount of fuel remaining is determined from the intensity of the gamma rays reaching the detectors. The rate-meter converts the pulses picked up by the detectors into dc voltage, and the quantity of fuel is shown in pounds on the indicator.

Accuracy of one part in 10^7 is claimed for airborne digital timer

AIRBORNE DIGITAL TIMER developed by Temco for USAF is accurate to one part in 10^7 and has a starting time accuracy of two milliseconds, claims the company. The timer will be used to provide real time for data correlation. It gives visual indications on six-digit numerical "clocks" as well as a video signal suitable for audio and/or graphic recording. Signals are in binary-coded decimal form.

Remote "clocks" used with the system use six-number indicator (nixie) tubes for presentation of real time. Up to 20 such clocks can be tied into the system. With just one remote clock and one reader control, system weight is 78 lb.

The system, says Temco, will automatically correct for progagation delay times.

•

FIVE flight simulators will be built by ACF Industries' Erco Div. for the Naval Training Device Center. Three will simulate the P2V-5 and two the P2V-7, both planes being versions of the Lockheed Neptune patrol craft. Latest tactical equipment for anti-sub warfare will be included in the simulators, says Erco.

Aluminum works so many ways for a strong and lasting peace

Shooting for the stars?

Alcoa goes to work immediately on defense projects

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ALCOA ALUMINUM

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Finding an **obstacle sensor** for copter flight

Under the Army-Navy Instrumentation Program, a study of obstacle-sensing is now in its third year at Du Mont. Here is a report on the possibilities examined in this study and on the conclusions it has reached.

by **R. P. Wakeman and Walton Graham,** Technical Director, Military Products Div., Allen B. Du Mont Laboratories, Inc., & Senior Scientist, TRG, Inc., resp.*

THE PROBLEM of sensing obstacles at night or in weather from a copter with a top speed of 200 kt boiled down to developing a sensor with zero to four miles range, 10 per cent range resolution, a forward, hemisphere angle of view, 1x1-deg angular resolution, and a frame rate of 10 frames per second.

There are *average* requirements, which might have to be modified for particular operating modes. For example, if the copter is hovering and searching the ground, considerably increased resolution is desirable. However, the four-mile range is no longer needed and, as the environment is stationary, the frame rate could

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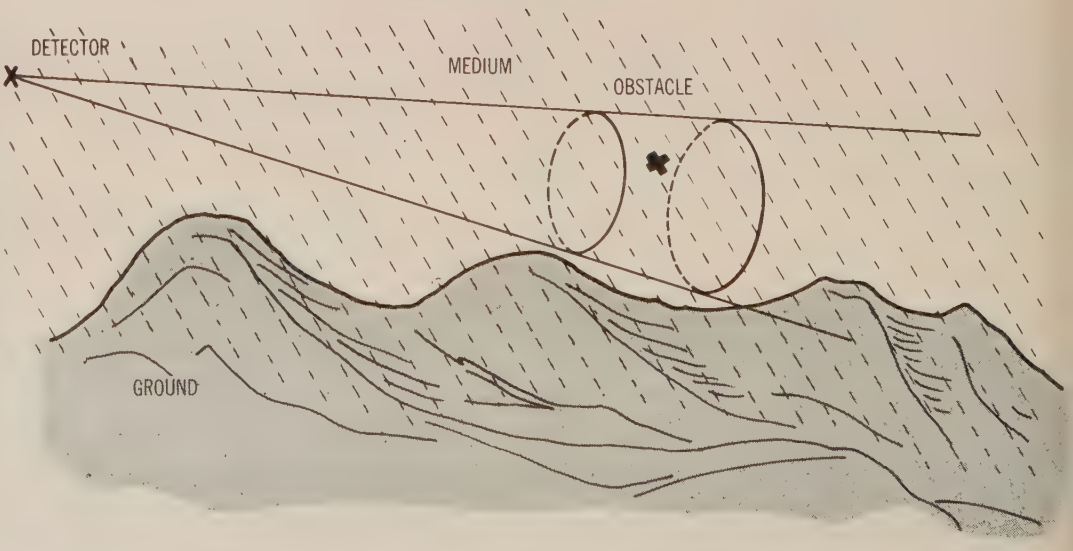

OBSTACLE-SENSING in precipitation. The distance between the circles represents the pulse length. The shorter the pulse and the narrower the beamwidth, the higher will be the signal-to-noise ratio. Du Mont proposes a one-degree beamwidth with a 0.02-usec pulse.

be reduced sharply. On the other hand, for top-speed cross-country flight, it might be desirable to increase range and frame rate at the expense of the viewing angle.

What type of sensor will meet the requirements we have set up? Under the Army-Navy Instrumentation Program (ANIP), Du Mont looked into nine possible techniques. Eight were eliminated because of inherent limitations:

- *Acoustic Detection*—Excellent range resolution, but that is the only advantage. Megawatts of power would be needed to get the desired range and, because of the low propagation velocity, it would take hours to scan a single frame.
- *Ultraviolet Radar*—This system would pose all the problems of visible light as well as others peculiar to its very short wavelength. In particular, the penetrating power of UV in fog or rain is considerably less than that of visible light.
- *Infrared Detection*—Fog or heavy rain attenuate IR essentially just as much as visible light. For example, to provide a range of one nautical mile in heavy fog, an IR source would have to emit about 10^{20} W peak power.
- *Power-Line Fields*—A power-line detection system poses problems because of its passive nature, its restricted application, and its uselessness if the lines are dead (as after a power failure).
- *Magnetostatic Fields*—This system would depend on perturbations in the earth's magnetic field to indicate the presence of obstacles. Obviously it would be insensitive to non-magnetic hills, would provide no direct range measurement, and would have poor resolution, and distant, large obstacles would be masked by nearby small ones.
- *Atomic Particles*—The range of alpha and beta particles in air is limited to a few centimeters and a few meters, respectively.
- *Gamma Rays*—These rays are extremely penetrating and would not be reflected from targets. Their energy would be transferred to photo-electrons in the absorbing target and would have a mean free path of only a few meters.
- *Passive Microwave Radar*—Passive radars lack range information. If the target is beam-filling, the received signal is independent of range, and nearby weak emitters (possibly including dangerous obstacles) might provide weaker signals than distant strong ones.
- *Active Microwave Radar*—Unlike the previous eight sensing systems, there are no fundamental objections to active microwave radar as an obstacle sensor. However there are plenty of practical problems.

Active microwave radar looks best

The ninth system type, *active microwave radar,* has no basic limitations, so let's look at it more closely. First of all, what frequency would be best for obstacle-sensing? "Microwave" covers a large slice of the spectrum—(one millimeter to 10 cm).

Basically, the frequency choice is determined by desired range and resolution vs permissible size, weight, and power consumption. Statistically, atmospheric attenuation and scatter increase with shorter wavelength. (However, this function contains many maxima and

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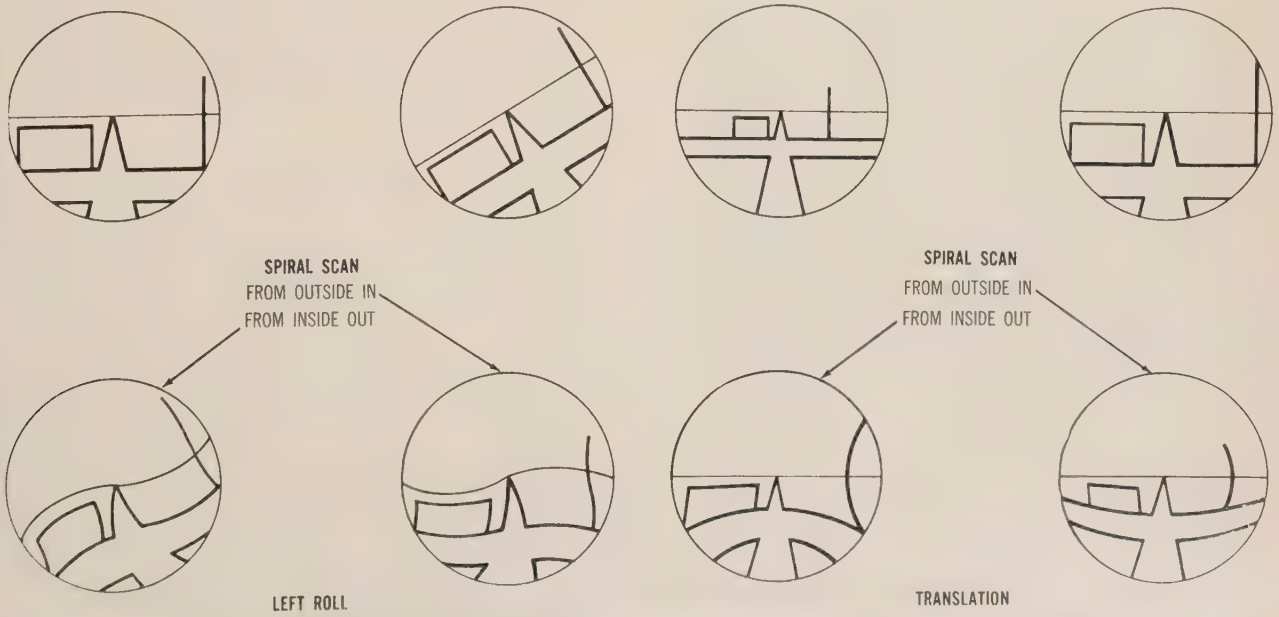
PICTURE DISTORTION due to spiral scan and translation or left roll. In the upper row, the first and third drawings show the picture at the beginning of scan; the other two, the picture at the end of scan.



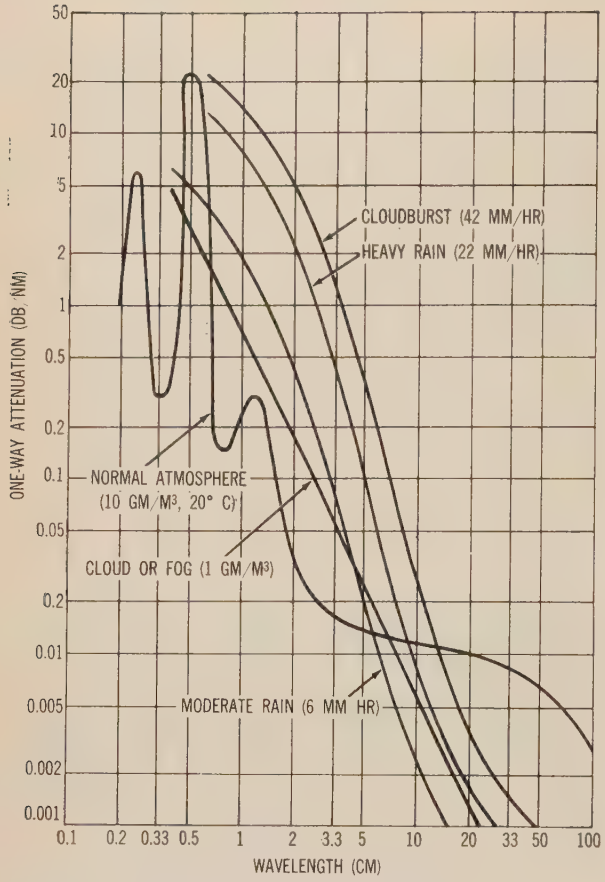


FIGURE 1: Fine structure of atmospheric attenuation with wavelength. The "window" at 4.3 mm shows relatively low attenuation at high resolving power; also, tubes are available at this frequency. (From Mueller, "Weather Effects on Radar;" Proc. IRE, Apr. '46.)

minima as the result of selective effects of various atmospheric components.) For a given range, size, weight, and power consumption increase with frequency. On the other hand, for a given resolution, size, and weight decrease with increasing frequency.

For four miles range and one degree resolution, a good compromise is the five-millimeter region. As the wavelength goes below this value, the power required for the desired range increases enormously; as the wavelength is increased beyond this value, the weight of the optics increases as the cube (of wavelength) and scanning power requirements go up, too. (It should be kept in mind that for other conditions—e.g., hover or high speed—the range requirement might be quite different and the optimum wavelength would be shorter for low velocities and longer for higher velocities.)

A look at the fine structure of the atmospheric-attenuation-vs-wavelength curve in the five-millimeter area shows a minor minimum at 4.3 mm (*Fig. 1*). Despite its rather sorry transparency, this "window" is the best we can get for obstacle-sensing.

We can divide all active microwave sensing systems into two basic categories:

- A *simultaneous* system corresponds to an eye, which views all the elements of the visible scene at the same time.
- In a *sequential* system, the elements of the scene are viewed separately in some predetermined sequence.

You can combine the two basic types so that several sequential systems they view different parts of the scene at the same time.

Let's first look at simultaneous systems. In the "floodlight approach" you're essentially using a TV camera sensitive to microwave energy rather than light energy. In heavy fog or rain, the energy returned from the nearby water particles completely masks that from distant targets, just as happens in the case of light. Unlike a light sensitive system, however, radar can have a very short time constant, and the reflection problem can be overcome to a degree by illuminating the scene with short pulses. Now the target echo is masked only by the rain return in its immediate neighborhood.

An analogous situation could be arranged for the visual case by pulsing a gas-discharge floodlight with short bursts and shuttering your eyes so that they viewed the scene momentarily a few microseconds after each flash. Such a system would still be quite inferior to radar, because of the much higher attenuation and scatter at optical wavelengths.

For the radar case, diffraction effects in the guise of sidelobes become important. Unless the optical aperture of a system is very large relative to the wavelength of the radiation, part of the energy will be contained in sidelobes significantly far removed from the main lobe. This effect, of course, degrades the resolution. It can be minimized by tapered illumination, but then you broaden the main lobe, which again lowers the resolution.

In the case of the human eye, the ratio of aperture to wavelength is about 5000. If you have 20-20 vision, the resolution limitation imposed by diffraction, discrete sensors in the retina, and the quality of the lens are all about equal, limiting the eye resolution to about one minute of arc. The ratio of aperture to wavelength in the radar system we are considering is only about 100, so that diffraction limits the system to about 60 minutes of arc, or one degree. Sidelobes would further degrade the resolution, and a large target (like the earth below) might represent a first return regardless of antenna direction.

An active radar is inherently protected against this sidelobe effect, since the antenna is used twice. The energy radiated in any wrong direction is well below that in the main lobe, and the antenna sensitivity on receiving the return from the wrong direction is much lower than that for the return from the right direction. If the first sidelobe is 20 db down, it will effectively be down 40 db in an active pencil-beam system.

Success becomes extremely doubtful

If, however, the entire field is pulse-illuminated, this advantage is lost, and the success of such a system becomes extremely problematical. There are other problems, too. We haven't even considered, for example, how we could build a 20,000-element mosaic (representing a one-degree resolution over a hemisphere) each of whose elements stores the transmission on time of the radar return as its spatial element.

We must conclude that the pure simultaneous system

will not meet our requirements (with realistic size apertures). When we now turn to sequential systems, we run into a basic difficulty: A range of four miles requires an electromagnetic wave round-trip transit time of about 50 usec. If our field of view takes in 20,000 1x1-degree elements (a hemisphere), it will obviously require a full second for one complete examination. To reduce flicker, we could show each picture 20 times a second, but the motion discontinuity would probably be intolerable and possibly dangerous.

Two hundred knots is over 300 fps, and we probably can't afford a 300-ft position error. Also, rotations of the vehicle can exceed 30-deg/sec, and it would be most disturbing to have the world jump around us in 30-deg leaps. Finally, since the location and attitude of the copter change during the sensing of one frame, the resulting picture will be distorted—the nature of the distortions being functions of the scanning sequence and gyrations of the vehicle. Obviously, we need a new, up-to-date picture 10-20 times each second.

The brute-force solution would be to use 10 radars, each on a different frequency and scanning a separate portion of the field. Power, weight, and volume would increase by a factor of ten. In addition, there would be problems in matching up the parts of the picture and in the use of multiple antennas.

One radar with varying frequency?

A somewhat more elegant approach would be to use only one radar with varying frequency. Theoretically we could sweep through a frequency band during one pulse and feed the ouput energy to an antenna in which the direction of the main lobe is a function of frequency. Thus we might examine all the elevation angular elements along a particular azimuth direction during one interpulse interval. The returns could be fed to a group of filters, the output of each of which would represent the return from the elevation element corresponding to the frequency to which the filter is tuned. We could then scan the azimuthal field 10 times per second, and the problem would be solved.

Since we would be increasing our information rate by a factor of ten over the purely sequential case of one frame per second, logically our power requirements should increase by the same factor. This actually hap-

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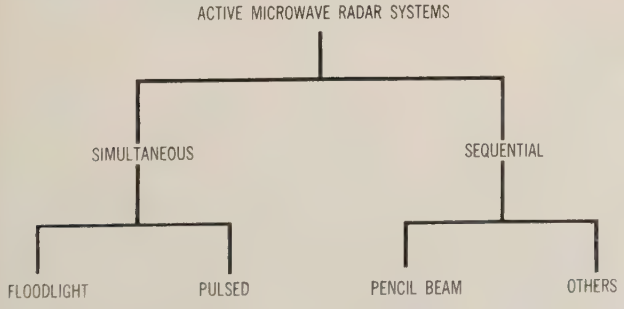
POSSIBLE active microwave sensing systems.



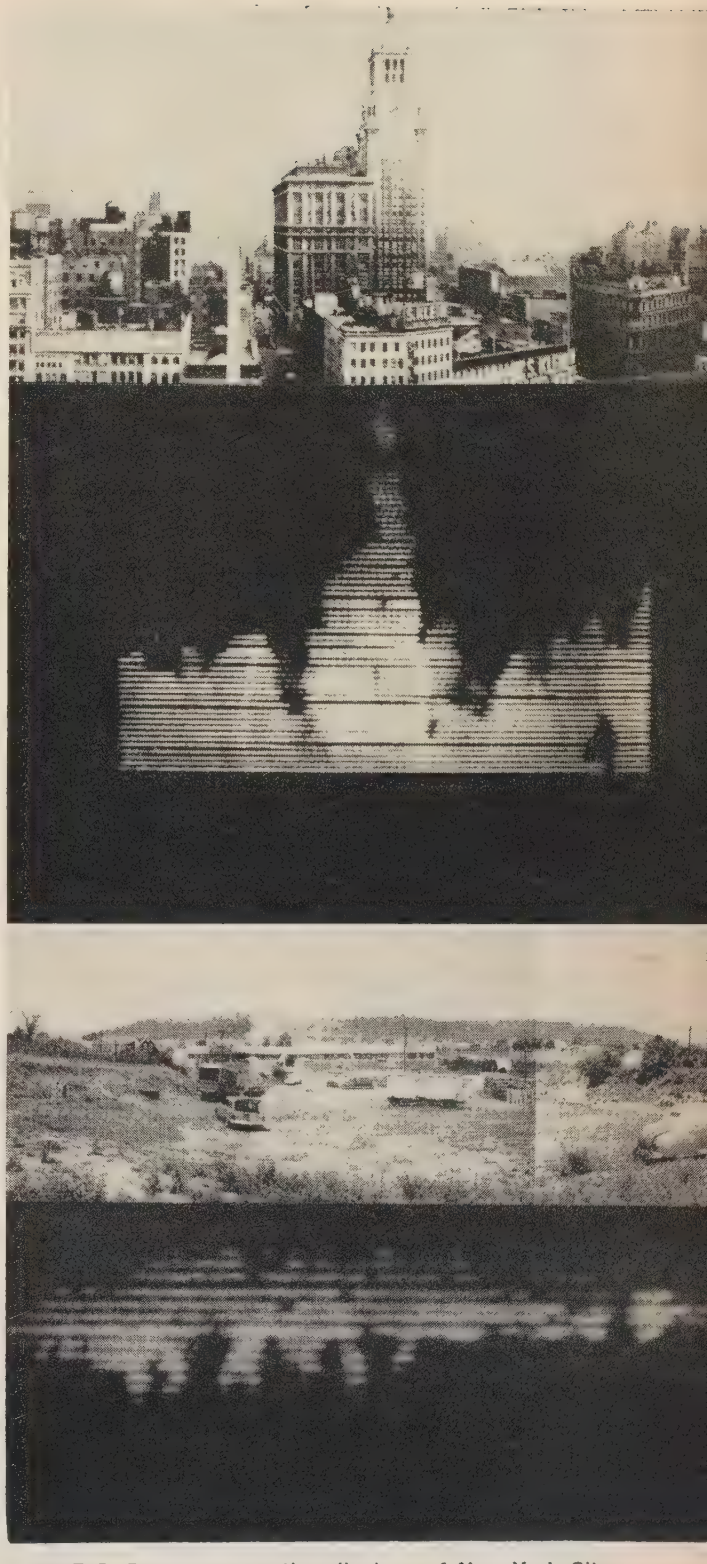


FIGURE 2: Range perspective displays of New York City (east side of Union Square from the west) and rural scene. Closer objects are brighter than distant ones. The degree of brightness depends only on the range and not on the amplitude of the radar return.

pens, and, of course, the weight of the powerplant increases as does that of the entire equipment. Another point is that the frequency controllable source and the frequency-swept antenna are well beyond the state of the art in the wavelength region we are talking about.

Monopulse system looks good at first

A monopulse system at first glance appears applicable to our problem. It actually would be if no two of our targets were at the same distance from the observer. Then we could send out an interrogating pulse and at each succeeding instant compare the phases of the signals from these antennas and correctly deduce the direction (azimuth and elevation) from which the return arrived. If, however, some range element contains more than one target, the phases of the antenna signals will represent the resultant of several returns and we won't be able to resolve the targets. All we could deduce would be that at least one target exists within the indicated range element, and we couldn't be sure that the indicated direction is within the solid angle actually subtended by the real targets. So monopulse as a solution is out, too.

What have we found out so far? That we must use a pencil-beam, scanning, active microwave radar system but because of the finite velocity of propagation we won't be able to get the desired information rate. Maybe we're confusing the product of spatial elements per frame and frame rate with true information rate. Certainly, if we examine successive frames taken at ten per second, we will discover a great amount of redundancy.

The aircraft motion can be integrated

An analysis of the apparent motion of objects as a result of a simple translation shows that they all move radially from the impact point and that the velocity of any of them is a function of its angular distance from the impact point as measured by the observer and its range from the observer. The apparent motion of objects as a result of rotational motion of the observer is much simpler, being a rotation of the entire world about the axis of the observer's rotation but in the opposite direction. For our case, the complete scene simply moves up or down as we pitch, laterally as we change heading, and rotationally about the roll axis as we roll.

Clearly it is feasible to integrate the aircraft motion from the time a target element is sensed until it is displayed and to use this integral for displaying the element at its true present screen coordinates. We call this process "data-updating." Considerable effort has been put into minimizing and simplifying its computations, solving its storage problem, etc. The result will be an up-to-date picture presented at least ten times per second as the result of data sensed once per second. In effect, this subsystem will replace nine complete radars.

To permit range inference, we propose, as a further refinement, to code range on the display. Close objects will be bright and distant ones dim regardless of the actual amplitude of the radar returns (*Fig. 2*).

Fully compatible with contact analogs

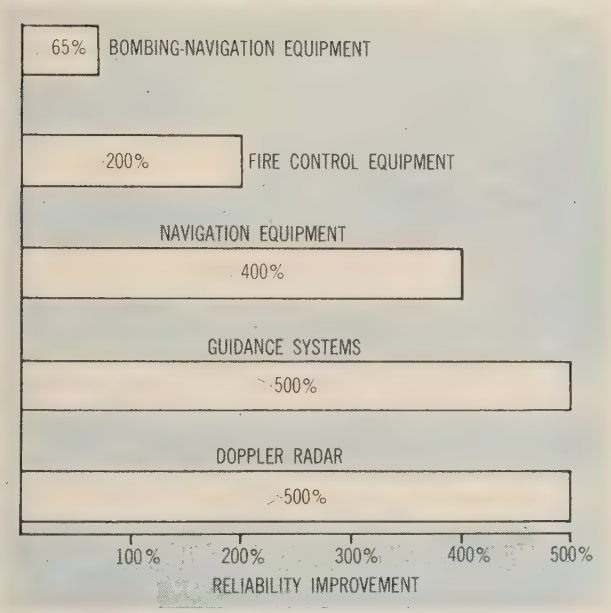
Since such a picture is a true perspective of the real world, it is entirely compatible with the various contact analogs now under development. The radar picture and the contact analog, it is intended, will be superimposed on the screen, along with certain other compatible information. A priority will be setup so that any imputs that represents something closer to the vehicle than another input will disable the second input at the appropriate position on the screen.

Concurrently with our study, an experimental program is being run to test the feasibility of our conclusions. The V-band (4.3 mm) art being in an embryonic state, waveguide components are being developed. A K_a-band volumetric scan radar has been installed in a truck, and tests are being made to determine the acceptability of the range perspective scheme and the severity of picture distortion without data-updating. Experiments are also underway to determine the feasibility of doubling the V-band frequency to 140 kmc.

The scope of the program has been extended to include VTOL and STOL aircraft. In their case, the greater range requirement will almsot certainly demand a longer-wavelength radar. Collateral studies are being made of the problems of integrating ground velocity, absolute altitude, and true airspeed measurements with the obstacle-sensing radar.—End

MILITARY COPTERS, like the Sikorsky S-55 (left), need obstacle-sensing for operations in low visibility and at night; commercial copters, like the Vertol 107, for low visibility approaches and landings.

How USAF expects to get reliable airborne electronics



PROOF OF THE PUDDING for USAF's reliability programs lies in the increase in the reliability of various types of airborne electronics over the last 2-3 years.

Highlights of USAF Electronic Equipment Reliability Program

- Specifying the reliability quantitatively as a contractural requirement.
- Reliability considerations in the evaluations of bidders proposals.
- Prediction of reliability in order to take corrective action early in the development-production cycle of the equipment without waiting for test results to disclose deficiencies.
- Monitoring the contractor's reliability program.
- A test program in accordance with AGREE recommendations to determine compliance with reliability requirements.
- Developing better components

Just what does USAF expect from its electronics contractors in the way of reliable design? What specs is it applying and what do they mean? This article, based on an interview at ARDC, answers these questions and others of importance in the crucial effort to improve the reliability of aerospace electronics.

by James Holahan, Electronics Editor

DESPITE tremendous progress, electronics simply hasn't kept pace with the demands of modern aircraft and missiles. Why? The answer is well known and needs only one word: unreliability.

There literally has been a deluge of "solutions" for the reliability problem in the technical literature. Many of these solutions have a great deal of substantial merit, but none supplies the whole answer. Actually, we know that there is no single answer. Unreliability is a complex malady and requires many types of remedies and treatments.

In an interview, A. L. Cleveland, Reliability Coordinator, Wright Air Development Division, and F. E. Wenger, Technical Assistant for Reliability, Air Research & Development Command, (the two reliability specialists who supplied the material on which this article is based), told SPACE/AERONAUTICS that one of USAF's first attempts to tackle electronics unreliability was ARDC Regulation 80-12, of May 18, 1956. This regulation contained a number of "reliability guidelines" for ARDC engineers and contractors. Here's a brief digest of the essentials of 80-12:

"To insure Air Force electronic equipments perform adequately, reliability must be given timely and adequate consideration in all phases of development, design and procurement. This regulation requires contracts to specify factors of reliability under defined environmental conditions such as shock, vibration, temperature,

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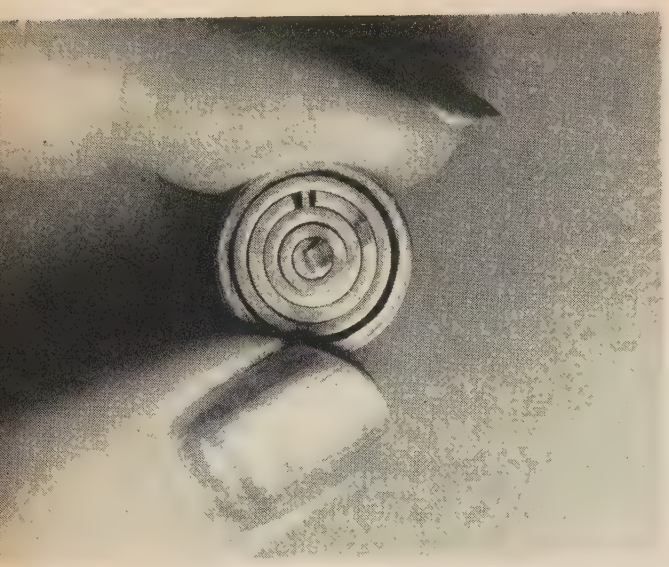
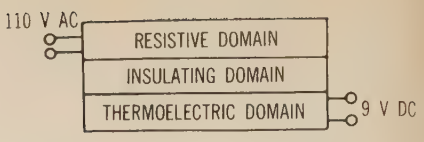
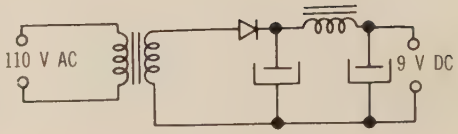




MOLECULAR DOMAIN



CONVENTIONAL COMPONENT

MOLECULAR ELECTRONICS is being pushed by USAF as promising one of the best answers for the reliability problem. This technique—which is being worked on by Motorola, RCA, Texas Instruments, Westinghouse, and others—improves reliability by reducing the number of parts and connections as well as the heat generated in electronic systems. The tiny "moletronic" amplifier at left was built by Westinghouse. It has a response of zero to 20 kc and, using a heat sink (not shown), an output of up to five watts. Right: Molecular power supply designed by Westinghouse shows how molecular and conventional circuits differ. When ac power is applied to the Westinghouse unit's resistive domain, heat is generated that passes through the insulating domain (which is an electric, not a thermal, insulator). Through the Seebeck effect, it is converted into electricity in the thermoelectric domain. The nine-volt output is ripple-free, since the heat flows at a constant rate.

etc. Every effort will be made to achieve optimum reliability through continued and strong emphasis of the objectives outlined from inception of the idea to procurement of the end item.

"Specific objectives are:

"(1) All specifications, exhibits, product descriptions, or other technical requirements will include specific requirements for reliability stated in quantitative terms, consistent with the state of the art, and take into consideration other design factors such as maintainability, cost, versatility, procurability, standardization, performance, etc. Deviation from specified reliability requirements will be granted only if performance or tradeoff values justify such action.

"(2) Contractual proposals will be evaluated as to the reliability program the prospective contractor proposes to follow. This includes:

"(a) inspection and quality control methods;

"(b) functional and environmental tests and procedures;

"(c) analysis procedures and methods to predict and measure reliability.

Separate reporting on reliability

"(3) During the course of a development contract, separate reports or a separate chapter in each program report will state the contractor's efforts to achieve reliability and his accomplishments in that direction. The contractor's progress toward meeting the reliability requirements of the contract will be determined by concontinuing analysis of the equipment design effort.

"(4) A separate report of each contract will be required which describes the following:

"(a) predicted reliability of the equipment as determined from data taken under specified test conditions;

"(b) the features of the equipment that the contractor considers the weakest from the standpoint of reliability and his recommendation on their improvement;

"(c) the measures the contractor has undertaken to increase the reliability of operation;

"(d) the improvement in reliability the contractor feels he has attained by the measures taken;

"(e) factors that will improve or decrease the reliability of the equipment in operation, including possible degradation due to variation in operating skills;

"(f) any other comments the contractor can make on the reliability of the equipment, component parts, assembly, or techniques."

Reliability insurance specs

Since the publication of 80-12, virtually all specifications for the development of electronic equipment have included reliability requirements and quality-assurance provisions. Recently, test procedures recommended by the Department of Defense Advisory Group for the Reliability of Electronic Equipment (AGREE) have been specified. Today, 100 production contracts include test procedures to determine compliance with the reliability requirements.

Two general specs, Mil-R-25717C(USAF) and Mil-R-26667A(USAF) now sum up what the Air Force wants its contractors to do to insure electronic reliability. These specs basically combine the requirements set by AGREE Task Groups 3 and 4.

Mil-R-25717C, entitled "Reliability Assurance Pro-

gram for Electronic Equipment," is essentially a management document. It requires the contractor to analyze and evaluate his proposed design, circuitry, parts, etc., and to prepare a series of estimates of the reliability that can be achieved with his design under the expected environmental conditions.

Naturally the contractor's first prediction of reliability will be highly theoretical. He is required to recompute the predicted reliability at various stages in the development and production cycles. As test data becomes available, the prediction becomes more factual.

If, at any time, the predicted reliability is lower than that specified in the contract, the contractor must make immediate corrections — by redesign, providing redundance, procuring better parts, providing environmental control, etc.

Contractor must describe methods

The spec also covers supporting efforts that must be considered in reliability programs. The contractor must report on what he is doing or plans to do in the following areas:

- organization for putting his reliability program into effect;
- reliability indoctrination of personnel;
- reliability testing facilities;
- analysis and prediction techniques;
- monitoring of subcontractors and suppliers;
- qualification and screening of components;
- design change review (where applicable);
- test procedures for demonstrating reliability;
- failure reporting, analysis of failures, and corrective action;
- workmanship criteria;
- handling, packaging, and shipping;
- storage and logistic-support requirements.

Mil-R-26667A, entitled "Reliability and Longevity Requirements, Electronic Equipment, General Specification for", requires the contractor to make a reliability and longevity design analysis and describes the measurement procedure, including test setup, selection of test items, and test environments, and the method for determining compliance with the requirements. It also reviews the types of data log that must be kept, the method of determining which failures are relevant (i.e., should be charged to unreliability of the equipment) and the analysis of reliability and longevity deficiencies.

Improved specs are being studied

Neither of the two specs is considered the last word in reliability evaluation. Studies are underway aimed at improving these specs. USAF hopes to find ways of:

- evaluating the reliability of a proposed design by an engineering inspection of the design techniques that will require only a single model of the equipment;
- categorizing basic circuits and evaluating a proposed circuit to determine its reliability;
- non-destructive testing to eliminate parts that would fail prematurely;
- relating electronic part failures to the conditions (voltage, temperature etc.) of use and determining reliability by computer methods.

Engineering inspection is needed because much of USAF's electronic equipment is bought in small quantities over long periods. Often reliability testing is waived to meet schedules. In any case, the purchase quantities are usually too small for reliability tests in accordance with AGREE methods whose results could be accepted with the necessary confidence.

Simple evaluation method foreseen

ARDC expects to develop a simple technique for evaluating the paper design techniques used in such cases. Obviously, a method that determines reliability before the design is frozen or the equipment is tested would save the Air Force millions of dollars.

Categorizing of circuits is necessary so that USAF will be able to specify reliability-proved preferred circuits, as it plans to do. When a circuit is found to be deficient by these standards, the contractor will have to check it according to a new procedure that is being developed.

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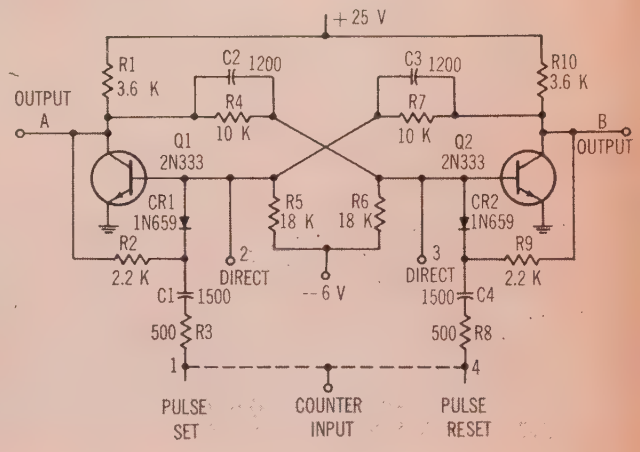
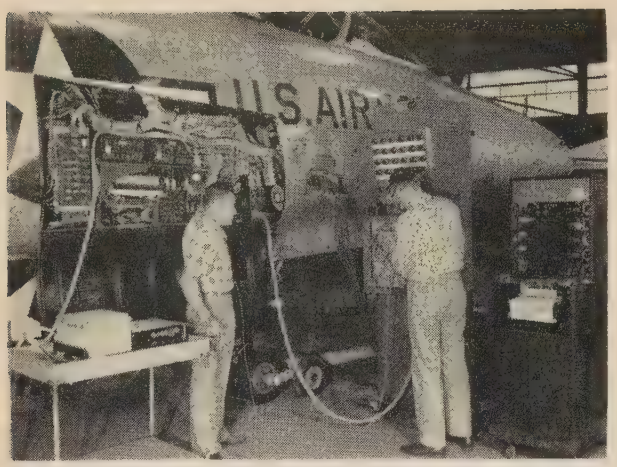
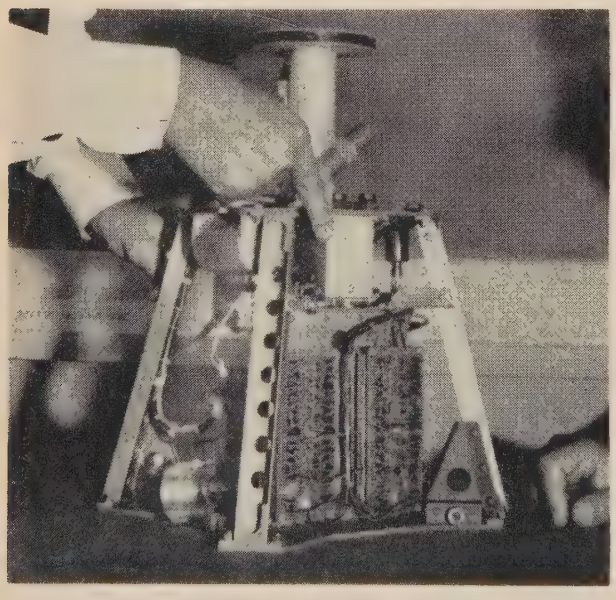


STANDARD CIRCUITS are one approach USAF is taking as it tries to insure reliability. There are 30 military standard electronic circuits, all based on the "preferred circuits" developed by the Bureau of Standards for BuWeps. USAF is studying their use. This saturating bistable multivibrator is one of the latest preferred circuits to be released by the Navy. (Unless otherwise stated, resistances are in ohms, capacitances in mocromicrofarads.) Component values assume a low-impedance driving source. (500 ohms maximum). R1, R4, R5, R6, R7 and R10 have ±5 per cent tolerance; all other components, ±10 per cent.



COMPLEXITY of electronic systems and components has increased with the trend toward "electronification" of more and more functions in aircraft, missiles, and space vehicles. For most aerospace vehicles today, the success of their missions depends on extreme electronic reliability. Two good examples of vital electronic equipment are the radiation instrumentation package to be shot to altitudes of 1000-2000 miles in a rocket nose cone for studies of the Van Allen belt (above) and the Minneapolis-Honeywell adaptive flight control system being checked out in its McDonnell F-101 test bed.



Mil-STD-439 already lists 30 accepted military standard circuits. Unfortunately, only a few of these are of the type used in modern airplane or missile electronics.

Non-destructive testing will get rid of the critical problem of eliminating unreliable parts before they go into equipment. USAF will determine from test data which parts are reliable. Unreliable parts will be examined to see if non-destructive tests could have been used to reject them. Except for expensive equipment testing and tight quality control, non-destructive testing seems to be the only thing that you can do to eliminate early failures.

The obvious way to make sure that a part is not used beyond its capability (e.g., with the wrong applied voltage or pulse, in too high a temperature, etc.) is to recheck the design. Hence a contract must require an application check by the contractor. USAF expects to write a requirement describing the application criteria to be used. The result of this check will be an accumulation of data during reliability testing and will give *failure rates* for the component reliability prediction.

Contractor engineers in the dark

Contractor engineers report that they don't know what failure rates to allow for electronic components under different conditions of use. For each contractor to try to get this information on his own is extremely expensive. This information must be gotten during reliability testing of equipment (without expensive parts testing) and during the parts manufacturer's life test sampling.

A joint AMC-ARDC ad hoc committee was formed to look into all aspects of the reliability programs of some 20 weapon systems contractors and a similar number of electronic equipment contractors. Any weaknesses found in these programs were discussed with the contractor. In general, the biggest failing lay in the lack of emphasis on designing reliability into the equipment in and excessive use of "fix-it" procedures.

As described so far, USAF's efforts to improve electronic reliability are based on the present concepts of assembling electronic equipment, using conventional components, wiring them together, using present connections types, and trying to make things smaller and smaller. This concept definitely limits the degree of reliability that can be attained. In fact, it is believed that this concept cannot even give us the high degree of reliability we need now and certainly not the reliability we will need in the future.

Trend to molecular electronics

ARDC therefore has started research on an entirely new approach to electronic equipment and system design: molecular electronics. Through the molecular concept, it intends to do away with the use of passive and active electronic components with all their wiring and interconnections. In their place it hopes to use grown material that will perform electronic functions by virtue of its inherent molecular structure.

Once electronic properties are properly correlated with the chemical, physical, and structural properties of matter, materials can be tailored to the required electric characteristics. Right now ARDC is trying to find better ways of growing materials with predetermined characteristics.

The goals of the molecular approach are:

- inherent equipment dependability,
- elimination of wasteful energy consumers,
- more efficient use of electric power,
- more functions per unit volume without an increase in either heat dissipation or maintenance problems.

At the start, ARDC expects to apply this new concept to the growing of functional blocks like amplifiers, multi-vibrators, oscillators, etc. Later on these blocks will be integrated into complete electronic systems.—End

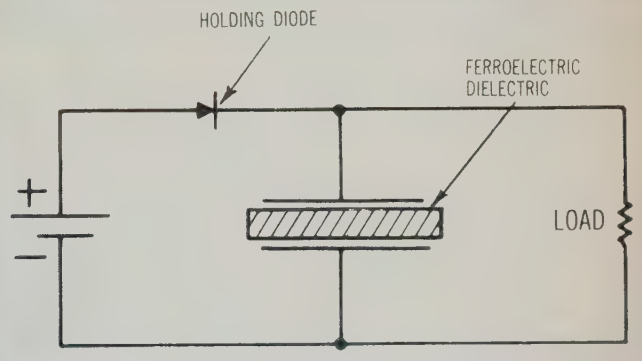
design digest

Ferroelectric power source

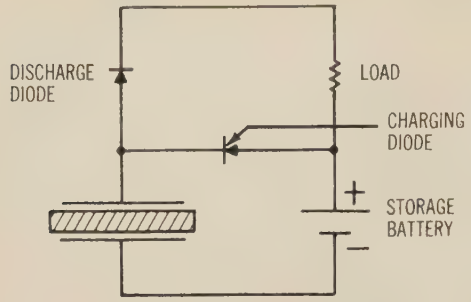
for space vehicles

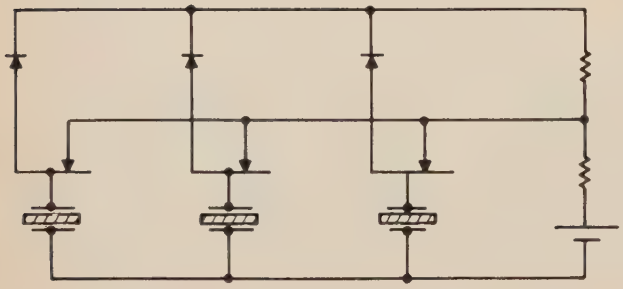
by Bernard Kovit
Associate Electronics Editor

HIGH VOLTAGE ac or dc power for satellites may be produced directly from solar or other heat energy by a new ferroelectric (FE) converter being developed by ITT Labs, 500 Washington Ave., Nutley, N.J. Unlike present solar batteries, which depend on light to supply dc at low voltages, the FE converter relies on temperature changes alone. In a typical satellite application, strips of FE material would be mounted on the exterior surfaces of the vehicle. Spinning would always keep some part of the FE array exposed to the sun. Because the exposed rotating surfaces alternately heat up and cool, the FE device is given just the conditions it needs to produce current. ITT Labs has already gotten outputs of over 1000 V from a single, dime-sized converter element. Theoretically, elements arranged in series could produce as much as 1,000,000 V. Write in No. 71 on the Reader Service Card for more information.



SATELLITE MOCKUP mounts plates of FE material. In basic circuit (above), energy conversion centers about raising the temperature of large FE dielectric capacitor about the Curie point (or temperature of peak dielectric constant). This process lowers K_e, steps up voltage, and produces energy gain.





CONVERTERS need not be designed to drain battery power. One practical method would be to use a battery in series with the load (top). After heating, a stepped-up voltage is fed through diode, load, and battery, returning the charge to the last. Bottom: Alternative dc scheme uses only a battery to prime several converter capacitors and overcome any leakage in these. The use of a charging resistor (or diode) in series with the battery keeps the output currents from discharging through the latter. FE capacitors would be temperature-cycled so that they would be at different points of the cycle at any given time. Recirculation of the total between the capacitors produces a dc current through the load. ITT engineers believe such an energy converter could be used to power a balloon-borne experiment and its monitors.

AC GENERATORS—Because ITT's energy converter is based on the temperature-cycling of FE capacitors, it's well suited for generating ac. For a spherical satellite, you could arrange two large capacitors at opposite ends, so that while one is heated by incoming solar rays the other cools. With alternate heating and cooling, the charge on the capacitors is driven back and forth through the load. Briefly, the charge accepted by the capacitor at Curie temperature is:

$$Q_c = C_c V_c.$$

The capacitor at temperature T_b accepts:

$$Q_b = C_b V_c.$$

This gives:

$$Q_c - Q_b = V_c(C_c - C_b).$$

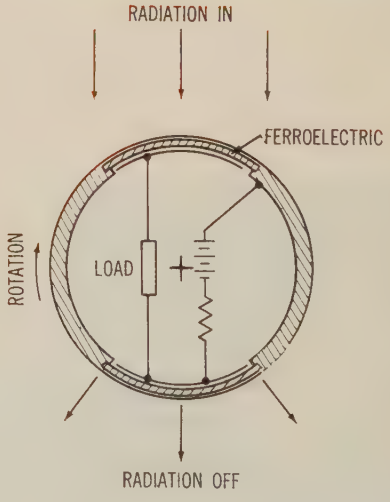
Since the charge is forced through a load twice in a temperature cycle, the average current is:

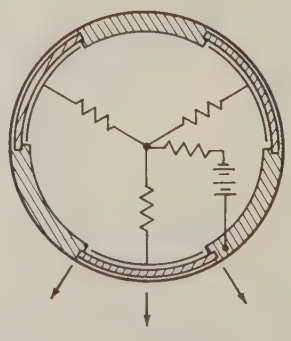
$$1 = 2f(Q_c - Q_b) = 2fV_c(C_c - C_b),$$

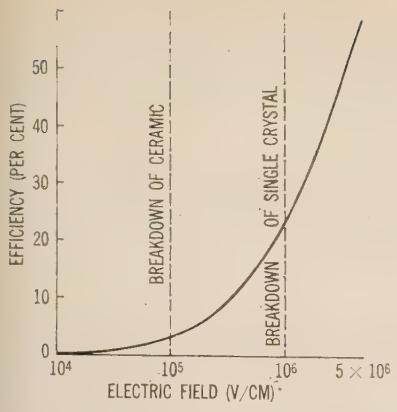
where f is the cyclic frequency. Peak voltage under no-load condition derives from the heating of one capacitor from T_c to T_b. Accounting for dielectric constant (K) this voltage is:

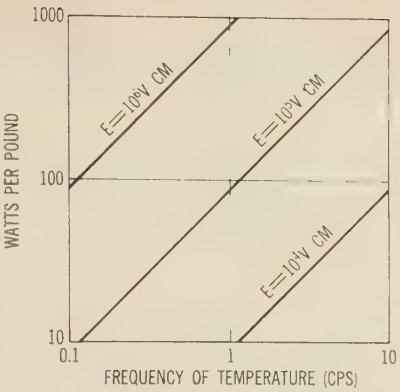
$$V_p = V_c C_c / C_b = V_c K_c / K_b.$$

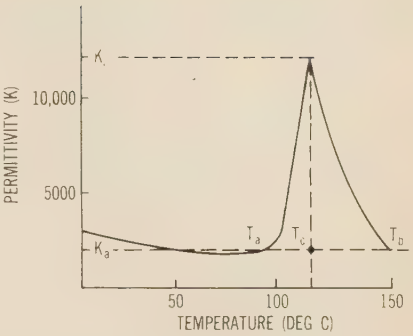
Lower right: Diagram of a three-phase ac generator.



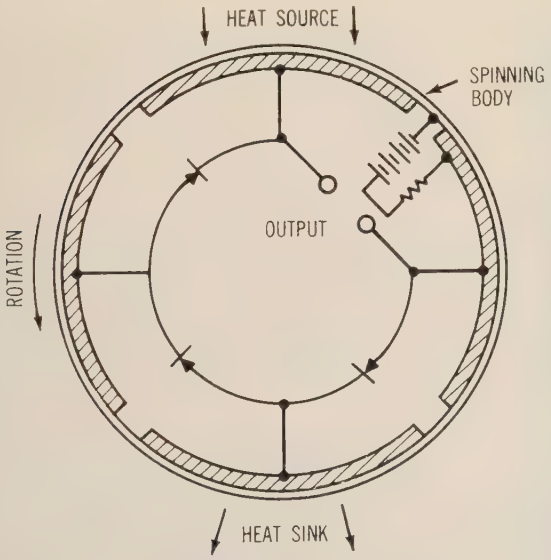






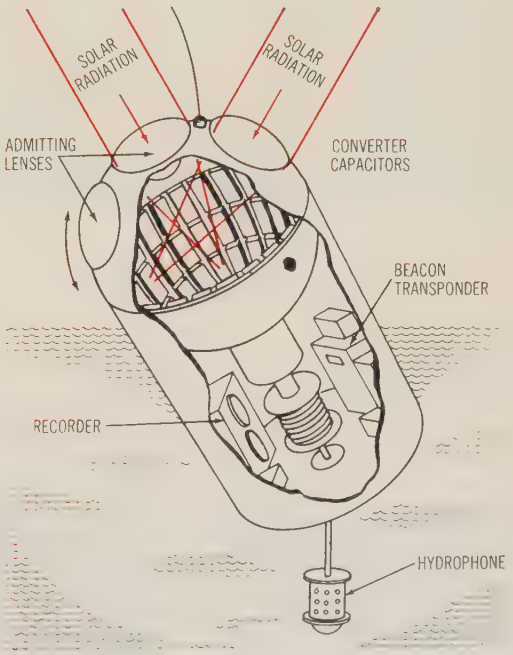


EFFICIENCY—ITT Labs engineer S. R. Hoh, inventor of the energy converter, notes that the FE device needs a high operating field (E) for efficient operation. Left: Limits of operating field strength for ceramic as well as single crystals. Center: Estimated output of converter per unit weight. Since FE ceramics cost less than conventional converter materials, a higher output per unit cost is claimed. Right: Permittivity (or dielectric constant) of barium titanate around the Curie temperature (T_c).



HIGH VOLTAGE GENERATOR—Ferroelectric energy converters inherently get higher output voltages than any other types, according to ITT Labs' scientists. Actually, with high charging voltage and a high K_c/K_b (dielectric) ratio, you should—and ITT Labs experiments did—get over 1000 V from a single relatively crude stage. Very high voltages are possible if you cascade several FE converter-capacitor stages (above) so that the output of each charges the next. In ITT Labs' HV design, the spinning body forms the common electrode. It's assumed the body is heated at the top to temperature T_b and cooled by radiation or heat sink at the bottom to T_c. Optimum output voltage of device with n stages is given by: $V_n = V_c(K_c/K_b)^n$ or $V_c(K_c/K_b)^4$ for the device shown, where V_c represents the battery voltage. Electrical charge Q is fed back into the right-hand capacitor and recirculated. In a spacecraft, the method could be used to power an ion propulsion system, says ITTL.

ASW APPLICATION—A possible anti-submarine warfare application might be a sonar buoy designed around an FE solar energy converter. Thus powered, the buoy could give extended periods of unattended operation (above). Of course, the buoy's center of gravity must be low enough to keep the lens section pointing normally upward. The rocking motion of the device on the ocean surface would point one or more of the lenses mounted in the upper turret at the sun. The lenses focuses the solar heat energy on individual ferroelectric plates mounted in the bottom half of the power turret. The on-off action produced by the device's bobbing motion lends itself to establishing the required thermal differential for FE energy conversion.



FABRICATION TESTS SHOW...

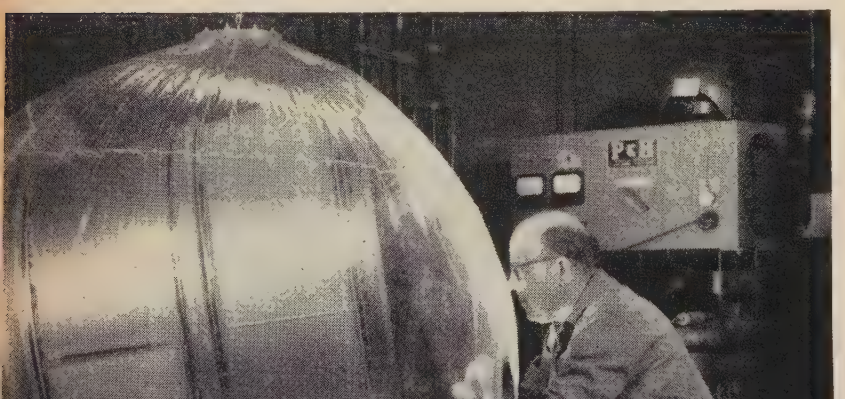
New Titanium alloy takes th

...in strength...in weight...in reliability...in pri

Titanium rocket-motor cases can be built at least 30 percent stronger (or lighter) than best available alternate metals; provide permanent corrosion resistance without protective coatings; withstand temperatures from –400°F to +800°F; will not absorb moisture which distorts critical parts in storage.

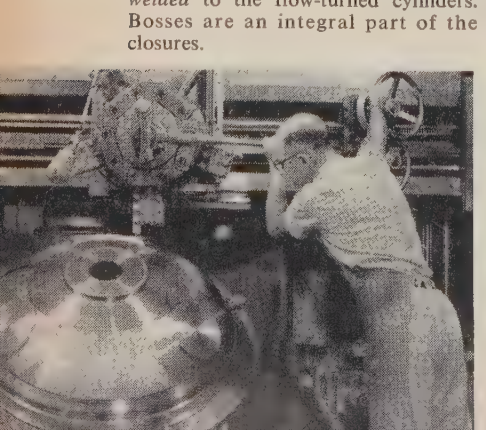
Completed assemblies give a spectacular two-way pay-off . . . immediately; provide a growth potential virtually unlimited.

The alloy: Ti-13V-11Cr-3Al, the beta titanium alloy. Now available from Titanium Metals Corporation of America at commercial lead-times (billet, 2-3 weeks), beta may well become the metals story of the year.

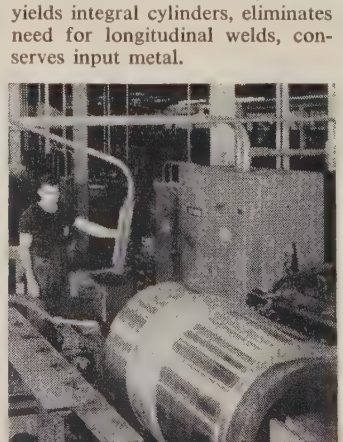


Welding of titanium at P&WA is based on the company's experience in production of more than 5800 jet engines containing titanium parts. Weld strength of beta titanium alloy is considerably improved by cold working the weld.

End Closure Titanium Forgings produced by Wyman-Gordon Company and machined by P & WA, will be *girth welded* to the flow-turned cylinders. Bosses are an integral part of the closures.



Flow-turning from roll-forged rings, makes feasible production of full-scale titanium rocket cases, since it yields integral cylinders, eliminates need for longitudinal welds, conserves input metal.



Pilot rocket-motor cases manufactured by & Whitney Aircraft from beta titanium Ti-13V-11Cr-3Al have been consistently b tested at levels in excess of 235,000 psi – a strength/density ratio of 1,340,000.

So successful has been its titanium pro that Pratt & Whitney Aircraft considers production of full-scale titanium cases ca easily realized. Estimated initial burst stren a conservative 180,000 psi – a burst stre density ratio of 1,000,000. Readily attain 1,250,000.

Reasons for optimism, spelled out by P&W engineers are:

1. **"The welded beta titanium alloy is capab considerable plastic deformation prior to ture. As welding has improved, the fa origins have moved into the thin wall (o case itself). With beta titanium, the case t but doesn't fragment.**

2. "We have successfully tested small scale tita cases with a steel equivalent yield strength beyond the 300,000 psi point. Considering the metallurgy of metastable beta titanium a is not far beyond its infancy, conservatively would predict strengths substantially higher the 320,000 psi equivalent as being c possible.

3. **"Beta titanium has to develop (only) 140,00 to be equivalent to 220,000 psi steel (whi almost near steel's top limits). But titan great potential above other alloys is reflect the high figure for practical (based o elongation) yield strength. At 180,000 titanium is equivalent to steel at 280,000 p 200,000 psi, beta titanium is equivalent to st 320,000 psi. 200,000 psi in beta titanium is p ble, and obviously would mean substantial creased payload to the moon or out into s**

4. "Apart from the strengths attainable in the titanium alloy, there is another property of siderable significance. Like other titanium a it has excellent resistance to corrosion normal atmospheric conditions, in salt wa well as in many other media.

"In considering the long time storage pro with rocket cases – a pit in a thin-walled c can be catastrophic – we would regard the titanium alloy, as the outstanding ma under consideration."

ead in rocket case construction

PRATT & WHITNEY AIRCRAFT SURVEY OF ROCKET CASE MATERIALS

GENERAL PROGRAM

The goal: "A material capable of reaching 300,000 psi yield strength in steel, with a considerable development margin."

The result: "While this goal had to be modified for steel cases, we have successfully tested small scale titanium cases with a steel equivalent yield strength well beyond the 300,000 psi point."

Conclusions: 1. "By exercising reasonable care, the development of full scale (steel) cases at 240,000 psi is perfectly feasible.

2. "Small scale (titanium) cases have been burst at stress levels as high as 260,000 psi . . . we are convinced that reliable cases can be manufactured (from titanium) at yield strength levels of 180,000 psi and over . . . at 180,000 beta titanium is equivalent to steel at 280,000 psi.

"At 200,000 psi beta is equivalent to steel at 320,000 psi. 200,000 psi beta is possible and obviously would mean substantially increased payload to the moon or out into space."

SPECIFIC COMPARISON: Corrosion Resistance

Steel: "All of the low-alloy constructional steels which have been discussed are subject to general rusting and, far more serious, to pitting type corrosion during machining, welding, heat treatment, pressure testing and final storage. Corrosion pits can act as severe stress-raisers and, in conjunction with hydrogen, have been demonstrated to cause catastrophic failure. It therefore goes without saying that pitting corrosion is a serious hazard."

Titanium: "Like other titanium alloys, the beta titanium alloy has excellent resistance to corrosion under normal atmospheric conditions, in salt water as well as in many other media.

"In considering the long-time storage problems with rocket cases—a pit in a thin-walled casing can be catastrophic – we would regard the beta titanium alloy as the outstanding material under consideration."

SPECIFIC COMPARISON: Strength

Alloy	Density	Practical Yield Strength (5% elongation)
Ti-6Al-4V	0.161# /in.³	155 ksi = steel at 270 ksi
Ti-13V-11Cr-3Al (Beta)	0.175# /in.³	180 ksi = steel at 280 ksi
		190 ksi = steel at 305 ksi
		200 ksi = steel at 320 ksi

Burst Test Results show titanium has provided consistent burst strengths of 235,000 psi – a burst strength/density ratio of 1,340,000. Failure occurs in the wall of the case itself – not the weld zones. Titanium cases do not fragment.

• Reliability and growth . . . the parallel

Pratt & Whitney Aircraft data reveal rocket-cases can *now* be built from beta titanium at strengths 17 percent greater than alternate metals, with beta titanium's strengths bounding forward under a minimum of development.

A striking parallel exists in liquid-fueled rocketry where titanium alloy Ti-6Al-4V was selected for helium storage bottles in the Atlas missile because of its strength/density ratio. Airite Products, Inc., a leading supplier of the titanium vessels, reports:

"Minor modifications in processing techniques and continuous tightening of tolerances and other variables have shown an increase from the original 5400 psig average burst pressure to the present average which is in excess of 9000 psig.

"This has been done without increasing the weight of the article by one ounce. Weight of the unit, incidentally is controlled to a tolerance of plus or minus one-half pound, on a weight of 79 pounds, and volume is controlled and guaranteed to plus or minus one percent."

While the performance of the titanium pressure vessels has been almost doubled, the price has been reduced almost 50 percent — and the missile has become operational.

• When a case fails, so does the missile

The price of completed beta titanium rocket-cases is now estimated at 2½ times the price of other metals, with titanium cases virtually in their infancy. Should the titanium cost difference remain, the pay-off would still be two-fold:

1. **Cost:** engineering time, would be greatly curtailed; expensive fuels (for example, 30 pounds of fuel are required in earlier stages for each additional third-stage pound) would be saved.

2. **Reliability:** titanium cases simply will not pit, rust, deliquesce, or become hydrogen embrittled.

Added together, these elements mean feasibility—feasibility supported by the commercial availability of the metal itself. Beta titanium alloy Ti-13V-11Cr-3Al is available from Titanium Metals Corporation of America at these lead times: billet, 2-3 weeks; bar, 3-4 weeks; flat-roll, 5-6 weeks. TMCA's metallurgical experience with the alloy is yours for the asking.

For further information, write for TMCA Data Bulletin 13, *All-Beta Titanium for Solid Rocket Pressure Chambers.* Extensive welding information is included.

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books

Aircraft Engines of the World, 1959/60, by Paul H. Wilkinson. The 17th volume in this series gives specifications of individual engines and also tables of current aircraft and their engines. Paul H. Wilkinson, 734 15th St., Washington 5, D.C. $15.

Electromagnetic Radiation from Cylindrical Structures, by J. R. Wait. This book presents a comprehensive theoretical treatment of slots (for slot antennas) on cylindrical surfaces. These surfaces include circular cylinders, wedges, cylindrically tipped wedges and elliptic cylinders. Pergamon Press Inc., 122 E. 55th St., New York 22, N.Y. $8.

True Position Dimensioning, by D. Bibeau & D. Sweet. This 28 page booklet presents a step-by-step explanation of the theories and practical application of this system, which is a method of specifying location tolerances for holes, slots, etc., from a specified theoretically exact location. Publications Dept., Scintilla Div., Bendix Aviation Corp., Sidney, N.Y. $3 per copy in lots of 1-10; $2.50 each for larger orders.

The Exploration of Space, Revised Edition, by Arthur C. Clarke. Intended for the general reader, this covers the problems involved in space exploration and some of the possible methods to be used. Harper & Brothers, 49 E. 33rd St., New York 16, N.Y. $4.50.

Aircraft Aerodynamics, by I. V. Ostoslavsky (translation). Three part translation of a Russian text on the methods of investigating and calculating aircraft motion. U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D.C. Set, $13.50. Parts I, II, $5 ea.; part III, $3.50. (OTS #59-11993-1, -2, -3.)

more on page 138

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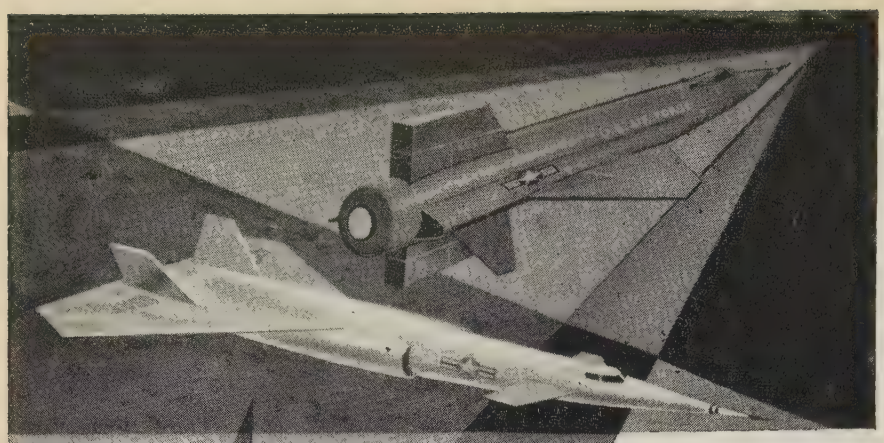

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Alcoa Structural Handbook. Sixth revision of this long-time designer's standby. This includes general updating of tables plus several new tables, including extensive data on Al-Mg alloys. Welded structure design is also covered. Aluminum Co. of America, 789 Alcoa Bldg., Pittsburgh 19, Pa. No charge, but limited availability.

The Upper Atmosphere, by H.S.W. Massey & R.L.F. Boyd. Discussion of phenomena of upper atmosphere studied during IGY. Techniques used in these studies, including rockets, satellites, balloons, etc., are described. Philosophical Library, 15 E. 40th St., New York 16, N. Y. $17.50.

ARDC Technical Symposium, 9-10 July '58, Dallas, Tex. This report includes papers given at the special, WADC sponsored symposium on materials and processes. Areas covered include separate sections on materials for structures, propulsion, electronics and special purpose. Materials R&D and the major forming, shaping and joining processes are discussed in other papers. U.S. Dept of Commerce, Office of Technical Services, Washington 25, D.C. $7. (Report PB 151627.)

Investigation of the Properties of Tantalum and Its Alloys, by Klopp, Schwartzberg, et al. Data on this important metal from a literature survey by Battelle Memorial Institute is given in this report. Subject matter is divided into four categories: process metallurgy, physical properties, chemical properties, metallurgical properties. U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D.C. $2 (Report PB 151562.)

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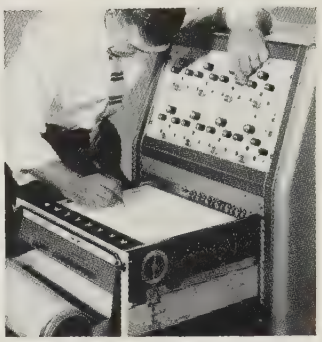


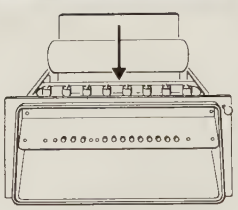
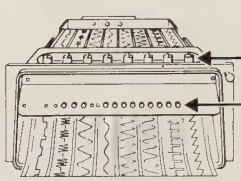


Chart paper loads from top



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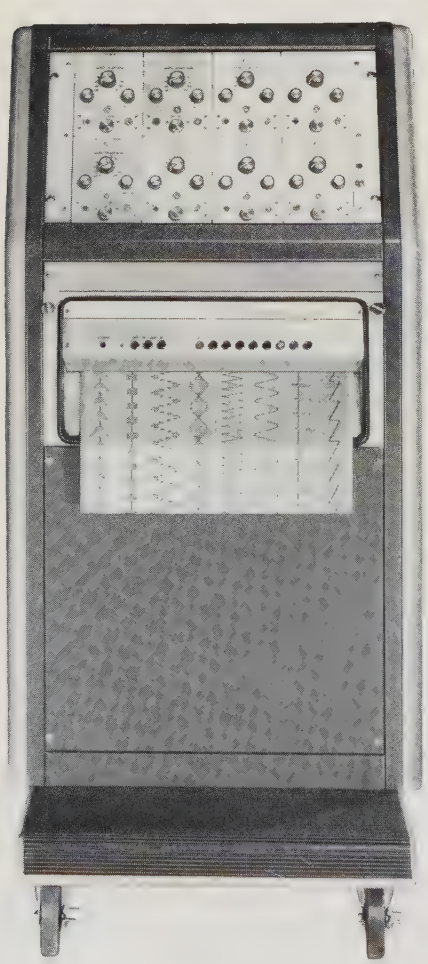

Why? Simply because Brush recording systems such as this 6-8 channel unit incorporate all of the known refinements in the art of recording by direct writing. No comparable system in existence today is as compact . . . as simplified . . . as reliable . . . as versatile. Note slide-mounted oscillograph and interchangeable "plug-in" signal conditioners that provide four vital functions in addition to amplification: high input impedance, zero suppression, attenuation and calibration.

Instantaneous rectilinear presentation gives clear, uniform and reproducible traces for precise readout of telemetry, computer, ground control and other data gathering operations. Further, this functionally designed system has a "pull-out" horizontal writing table for convenient annotation and reading . . . without turning off the recorder! Check these and many other advanced features for yourself and you'll see why *no one* is as qualified as Brush. Call, write or wire for complete details.

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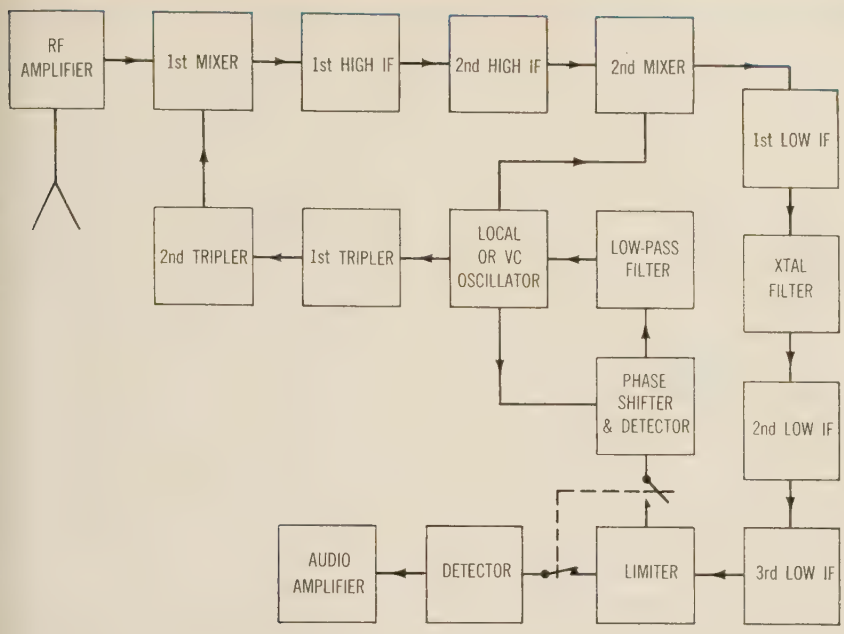

TRANSISTORIZED receiver for interplanetary tracking and communications. Eighty per cent of the receiver could be built from existing components. Only the RF amplifier and second tripler need improved transistors. Today, subminiature ceramic tubes could be used in these stages.

Radio link to space

can be built with today's hardware

There are three basic methods of increasing system gain in a long range radio link: boosting the transmitter power, making the antennas more directive, and increasing the receiver sensitivity. This article tells what these methods can achieve for earth-space communications.

by Kurt H. Meissner, Radioplane Div., Northrop Corp.*

IN SPACE, distance is the greatest obstacle to long range tracking and communications with the atmosphere adding a few complications. During the International Geophysical Year (IGY), much was learned about tracking and communications at interplanetary ranges. A few basic facts now seem to be certain:

- Only line-of-sight transmission will be feasible.
- The usable frequencies lie between 100 and 2000 mc.
- Receiver bandwidth must be kept to a minimum.
- CW and very-long-pulse systems are better than pulse systems.
- Earth stations must be in noise-free locations.
- Earth antennas should have maximum gain and circular polarization.
- Information-theory techniques (e. g., phase lock) must be added at the ground station.

To get a better understanding of space communications let us look at an arbitrary radio link to see how close it comes to meeting the requirements. Let's consider the path from earth to Mars, a distance of approximately 10^8 miles. At 100

more on next page

* Radioplane Div., Northrop Corp., 8000 Woodley Ave., Van Nuys, Calif.

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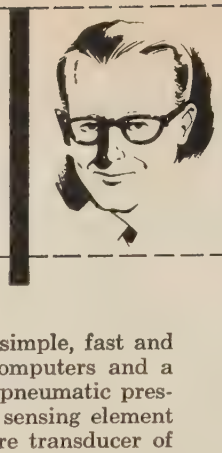
Engineering notes from the

SMI REPORTER

By STANLEY M. INGERSOLL, *Capabilities Engineer*



Report No. 2 TS 539 Test Set

Our new TS 539 Test Set answers the demand for simple, fast and accurate means of flight line testing of air data computers and a universal test device for the generation of accurate pneumatic pressures in a wide variety of applications. The critical sensing element within our TS 539 is an SMI force balance pressure transducer of extreme sensitivity and accuracy.

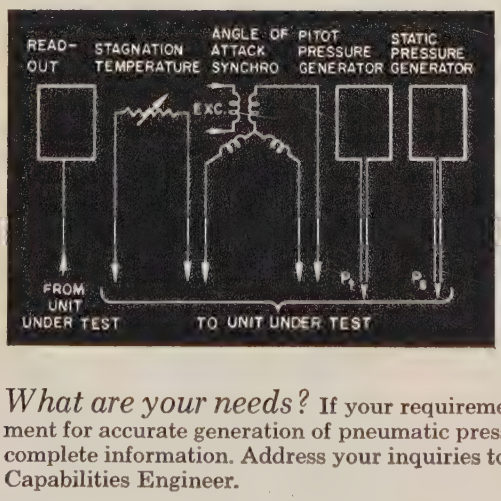
As two examples of widely different points in a typical flight envelope, the TS 539 generates pitot and static pressures to simulate an aircraft flying at Mach 0.8 at sea level to an accuracy of ±½ millimach with an altitude accuracy of ±7 feet; at a speed of Mach 3 at 70,000 feet, Mach accuracies are within ±5 millimachs and altitude accuracies are within ±90 feet.

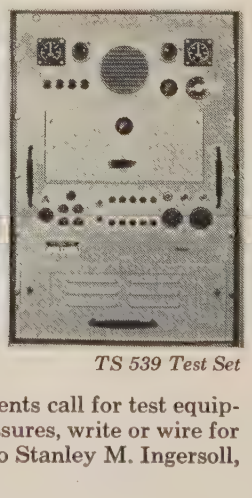
The TS 539 also includes capability of simulating angle of attack and stagnation temperatures.

In the TS 539, a completely self-contained Precision Dual Pressure Generating System supplies the necessary inputs simulating the broadest range of flight conditions. Panel facilities are provided for read-out of selected signals and provision is made for routing of other signals to a digital multimeter. Comprehensive tests may be accurately and quickly performed by semi-skilled operators. Automatic and manual control is provided to select outputs which simulate conditions within aircraft flight envelopes. Unusual flexibility is inherent in this design that permits ready adaptation to any test requirement involving the need for precision control of pressure sources.

Typical Performance Specifications

Static Pressure, P_s	25 to 800 mm. Hg
Altitude, H_p	—1500 to 75,000 ft.
Total Pressure, P_t	50 to 1270 mm. Hg
Differential Pressure, Q_c	25 to 1020 mm. Hg
Stagnation Temperature, T_i	—20 to 120 Deg. C.
Angle of Attack, α_i	Full 360 Degrees





TS 539 Test Set

What are your needs? If your requirements call for test equipment for accurate generation of pneumatic pressures, write or wire for complete information. Address your inquiries to Stanley M. Ingersoll, Capabilities Engineer.

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Los Angeles Division
12500 Aviation Boulevard
Hawthorne, California

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mc, the free-space loss amounts to 254 db. Our receiver would be a narrow-band type with a threshhold sensitivity of —160 dbm—even today, such a unit is not difficult to build.

Let us further assume a gain of 50 db for both antennas. The spaceborne transmitter may have an output power of 10 W, or 40 dbm. With these gains, the totals for the space-earth link would be 90 db for the transmission gain (output power plus antenna gain) and 250 db for the system gain (receiver sensitivity minus transmission gain).

The ground-to-space link yields similar results. While the spaceborne receiver must necessarily be simpler, the ground transmitter can be 50 db more powerful. Clearly a system as we are looking for is feasible.

To take care of fading, noise, and system losses, an additional 30 db is needed. This can be gotten by improvements in: transmitter power, antenna gain, and receiver sensitivity.

There's no problem in increasing the power of the spaceborne transmitter to 100 or 1000 W. The problem is the power needed to run this transmitter for several months (though perhaps intermittently). At present, it must be assumed that the final stage of a 100-W UHF transmitter will be a vacuum tube. An efficiency of 30 per cent is excellent for tubes, so about 400 W power would be required for the transmitter.

Primary power would come from batteries. Chemical batteries can supply about 40 WH/lb, atomic batteries about 700 WH/lb, and the hydrogen-oxygen energy cell about 900 WH/lb. Solar batteries convert sunlight with an efficiency of about two W/lb. We can see that high power and/or low efficiency transmission imposes a tremendous penalty.

As better transistors become available, it will be imperative to fully transistorize the spaceborne transmitter. This would probably increase the overall efficiency to about 60 per cent, but a UHF transistor output of over 10 W still seems unlikely for the next five years.

Another important factor in the spaceborne unit is stability. Present transistor oscillators offer stabilities on the order of 10^{-8}. This is not enough for interplanetary ranges—

nort-term stabilities of 10^{-10} are esirable.

Cooled quartz crystals have been uilt for lab use with a Q of 10^7. his is enough stability for the re-uired accuracies, but these lab nits aren't yet fit for the rough nvironment of space probes.

During the IGY, considerable ef-ort was put into the development f highly accurate high gain ground ntennas. The mechanical accura-es of the Minitrack and Micro-ck antennas can hardly be sur-assed. The design problems in get-ng these accuracies are reduced mewhat by the use of higher equencies. Circular polarization ust be used because of the un-redictable polarization of the ar-ving wave. Interferometer systems e recommended to reduce dele-rious effects of noise and inter-rence.

The gain of the ground antenna n probably be increased to around) db. However, this increase ould narrow the beamwidth so uch that the search problem ould be considerable should track temporarily lost.

The vehicle antenna seems to fer the best opportunity for gain. cause of the unpredictable atti-de of the space vehicle, one is clined to use omnidirectional an-nas with no gain. However, if her the vehicle or the antenna re stabilized, fairly broadband rectional antennas could be used, hich would supply a gain of 10-20 . If the antenna could be ex-nded after the vehicle has left the nosphere, mechanical stabiliza-n would be aided by the friction-s environment. Electronic stabil-tion of the beam seems more omising, however.

Different approaches are needed the ground and the spaceborne ceivers. Receiver design, filter, d IF and audio amplifiers already close to their theoretical phys-l limits. The only improvement the near future will come from id-state RF amplifiers. Masers d Mavars or parametric ampli-s will probably cut noise figures ow one db and offer threshold sitivities of —180 dbm, which is se to absolute zero temperature. More work, but of a different ure, remains to be done on the ceborne receiver. It should be ly transistorized for minimum wer consumption. Stability is der to maintain, because of the

more on next page

Engineering notes from the

SMI REPORTER

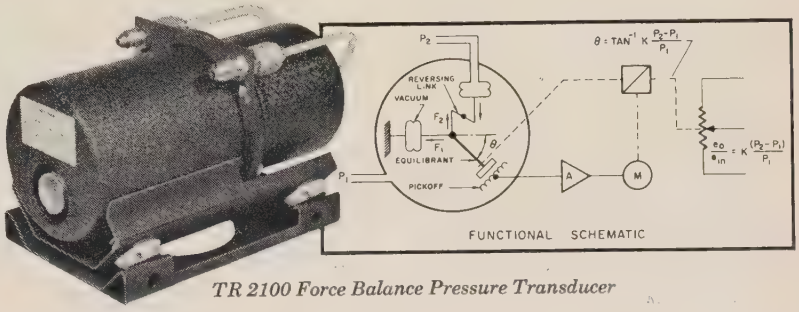
BY STANLEY M. INGERSOLL, *Capabilities Engineer*

Report No. 3
TR 2100 Force Balance Pressure Transducer

SMI is now producing a new, unusually flexible Force Balance Pressure Transducer that features both electrical and mechanical output capabilities. Extreme sensitivity and accuracy is combined with unique flexibility in the TR 2100. It is available in ten models and the functional "Mechatronics" packaging philosophy permits prompt delivery of standard transducers covering a wide range of applications: from subsonic to supersonic aircraft, drones and missiles, to ground support, and test equipment. The functional schematic, shown below, illustrates the basic force balance principle. The transducer measures 3¾" dia. x 7" long, weighs 3.25 lbs., without shockmount, and conforms to MIL-E 5400 and 5272.

Typical Performance Specifications

Type No.	Inputs Physical	Computation	Output Range	Output Form	Accuracy	Threshold
TR 2100	Total & Static Pressure	Mach No.	$0.1 \leq M \leq 1.0$ $-1000 \leq$ Alt. $\leq 100{,}000$ ft.	Pot. or Synchro	± 0.001 M	0.0001 M
TR 2100-2	Total & Static Pressure	Mach No.	$0.12 \leq M \leq 3.0$ $-1000 \leq$ Alt. $\leq 100{,}000$ ft.	Pot. or Synchro	$0.003 \leq M \leq 0.015$	0.0002 M
TR 2100-5	Static Pressure	Altitude Deviation	± 500 ft. From −1000 to + 80,000 ft.	Pot. or Synchro	—	2 ft.
TR 2100-6	Static Pressure	Pressure Altitude	−1000 to +100,000 ft.	Dual Speed Synchro	± (25 ft. + 0.25%) −1000 to 5000 ft. ± (40 ft. + 0.25%) 5000 to 80,000 ft. ± 0.5% to 100,000 ft.	2 ft. to 40,000 ft.
TR 2100-7	Turbine Outlet (P_7) And Compressor Inlet (P_2) Pressures	Engine Pressure Ratio (E.P.R.)	$1 \leq$ E.P.R. ≤ 4	Pot. or Synchro	7 in. $\leq P_2 \leq$ 30 in. $1.9 \leq$ E.P.R. ≤ 2.6 ± 0.010 E.P.R. 3 in. $\leq P_2 \leq$ 40 in. $1.0 \leq$ E.P.R. ≤ 4.0 ± 0.020 E.P.R.	0.0005 E.P.R.



TR 2100 Force Balance Pressure Transducer

For more information and complete operating specifications on the TR 2100 Force Balance Pressure Transducer, write or wire today. Address your inquiries to Stanley M. Ingersoll, Capabilities Engineer.

SERVOMECHANISMS, INC.

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Hawthorne, California

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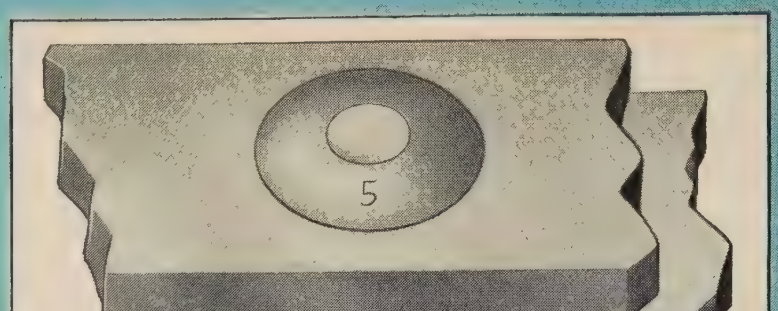

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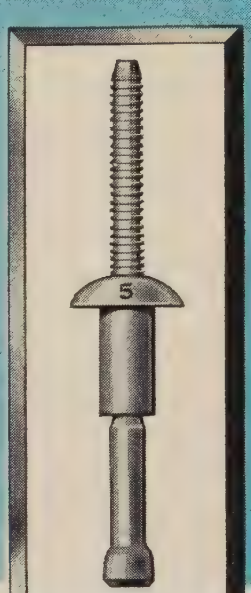

The new Cherry "9000"* Series MS type rivets are now a part of our standard product line, along with our familiar knob stem rivets.

Cherry is again FIRST to provide grip markings on the rivet head—for easy identification in bins or work boxes, plus positive visual inspection after installation.

Fully approved under MIL-R-7885A, the new Cherry "9000" Series rivets are available in your choice of metals, and are installed with existing serrated stem pulling heads.

For those who prefer serrated stem type blind aircraft rivets, the Cherry "9000" Series completes the line which includes the new Cherrylock "2000" Series Mechanically Locked Stem with flush fracture, the Cherry High Clinch Series rivets—"600", "700", "800"—and the Cherry Standard MS line of knob stem rivets—the "100" and "500" Series. For information write: Cherry Rivet Division, Townsend Company, Box 2157-P, Santa Ana, Calif.

**Patent pending*

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difficulty of controlling the environ ment. The solid-state low noise RF amplifiers need either considerabl pump power or cooling with heav and complex plumbing. So it ma be better to use a transistor o unvistor RF amplifier.

The first consideration in systen design is the choice of frequency. Frequencies below 100 mc suffe from ionospheric reflection, whil frequencies above 2000 mc ar limited by atmospheric absorption Within the 100-2000-mc band, th choice seems to be purely a matte of making the fullest use of exist ing components. The physical siz of antennas points to the highe frequencies, the efficiency of tran sistors to the lower ones. Assumin a further improvement of transist ors in the next few years, abou 600 mc for the ground-to-spac link and about 500 mc for th space-to-ground link seem good The two frequencies cannot b separated too widely, because the will probably use the same vehicl antenna.

The next consideration is th bandwidth. Bandwidth buys info mation rate, but at the expense c noise. Since most data on a spac flight will occur over seconds c more (or can be integrated), narrow bandwidth is acceptable. range is measured by Doppler shif it may be necessary to accomm date frequencies up to 10,000 cp especially at the closer ranges.

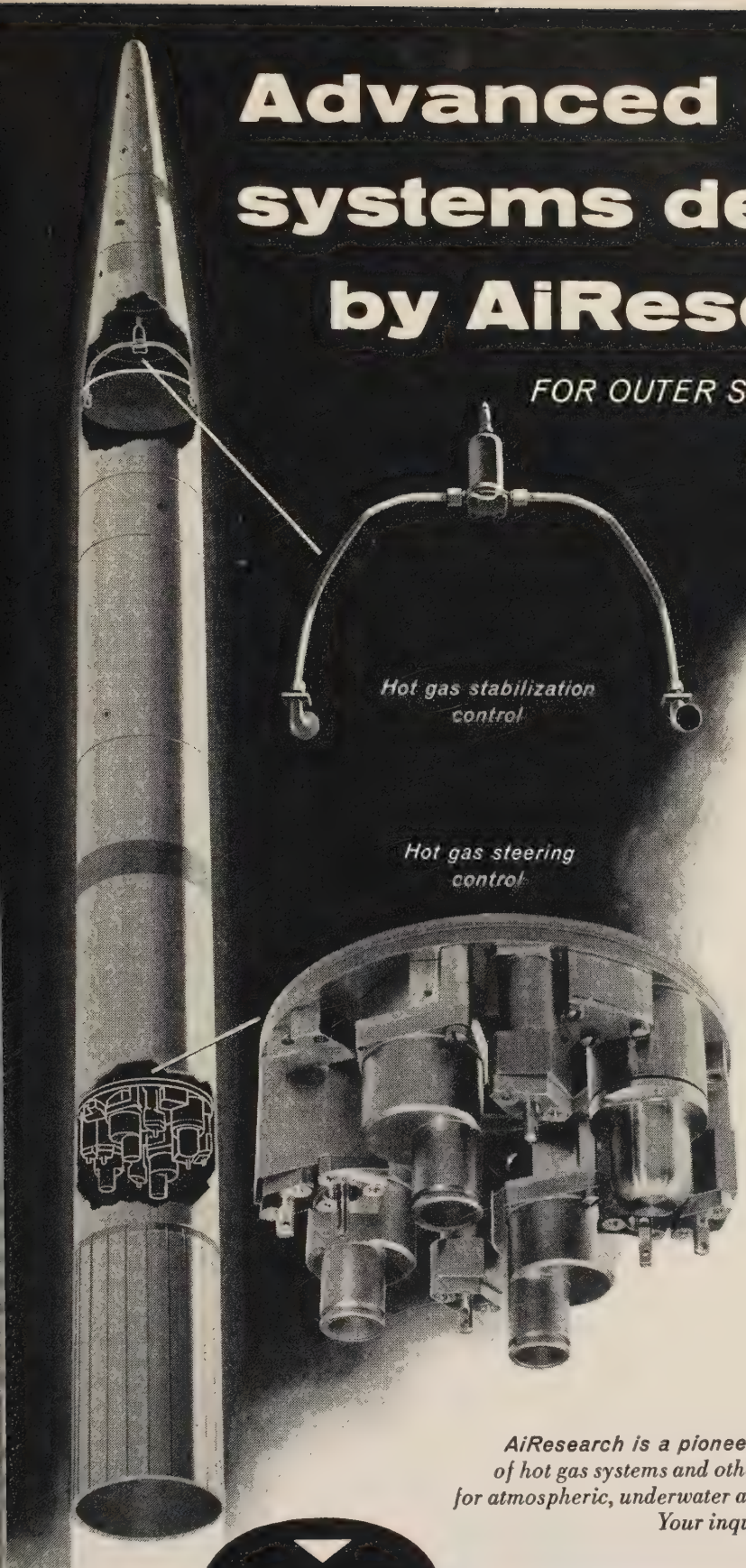
It is possible, by the way, to d termine frequency deviations several kilocycles with a narrow band receiver on the phase-loc principle, but the Doppler metho is dependent on the oscillator st bility. It seems preferable to us phase measurement of a rangi tone for range measurement. frequency of 10 cps covers abo 9000 miles in 360 degrees of wa travel. There is good reason to b lieve that other measurements, the continuity from launch, wi take care of the ambiguity.

The accuracy of phase measur ment is determined by the pha stability of the loop and by th noise in the receiving system. In narrow-band system the latter ca be held below one degree. A tot error of three degrees would pe mit range measurements to abo ±80 miles. It is possible that th uncertainty in the propagati velocity may become the limiti factor.

more on page 1

Advanced hot gas systems delivered by AiResearch

FOR OUTER SPACE, ATMOSPHERIC AND UNDERWATER STEERING



AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

AiResearch is a pioneer, leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions. Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

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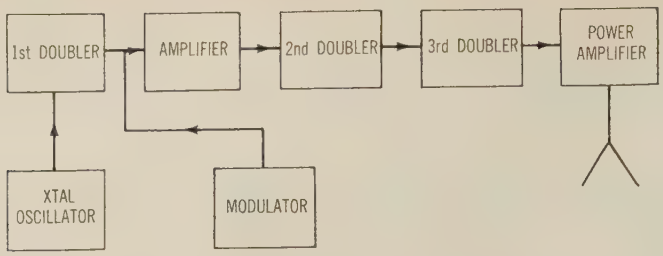

HYBRID transmitter uses transistors for all stages except the third doubler and the RF amplifier. As transistors with higher frequencies and powers become available, even these stages could be transistorized.

There is another disadvantage in making the system bandwidth narrow, which is best compared to the difficulty of acquiring a target with a very narrow antenna beam. Unless this beam is aimed quite exactly, there is no return. To the three-dimensional search problem, the bandwidth adds a fourth dimension, the frequency band.

Two-way communication with a space probe should be provided, but for the longer ranges voice communication seems impractical —a bandwidth of 3000 cps would be needed. Radiotelegraphy, though not as convenient, can be handled with a bandwidth of only about 100 cps.

The advantages of a phase-lock system decrease as the bandwidth is increased. The same link might be used for three purposes, for each of which the intelligence would be taken from a different point of the system:

- CW transmission would determine short-time frequency;
- FM ranging tone transmission would measure distance;
- subcarrier modulators would be inserted—by breaking in between receiver and transmitter—for telemetry and communication.

A bandwidth of 100 cps should be sufficient for most applications.

Two areas of immediate improvement are electronic antenna beam stabilization and airborne transponder design. The latter may require a selection of frequencies on a national or international level and based not on today's possibilities but on a reasonable estimate of the time needed for component improvements.

The *Block Diagrams* show the layout of a suitable airborne transponder. Eighty per cent of the receiver part can be built with current equipment. Only the RF amplifier and the second tripler need improved transistors, though even these two stages could be built with subminiature ceramic tubes.

The main design problem of the transmitter is the stability of the transistorized crystal oscillator. The last two stages can use vacuum tubes, although the last doubler undoubtedly could take a transistor in a few years. In the design of the power amplifier, the emphasis must be on efficiency. Present designs should concentrate on a 10-W transmitter, allowing for an additional output amplifier to boost the power to 100 W later on. —End

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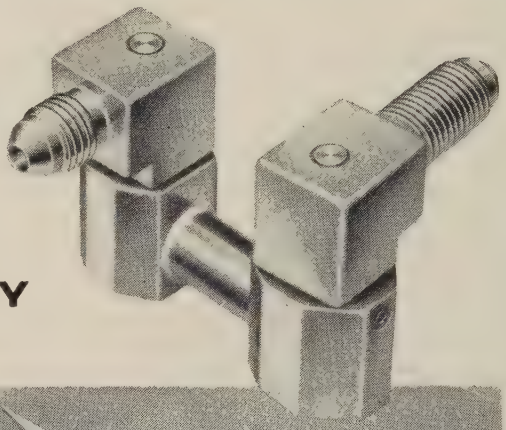

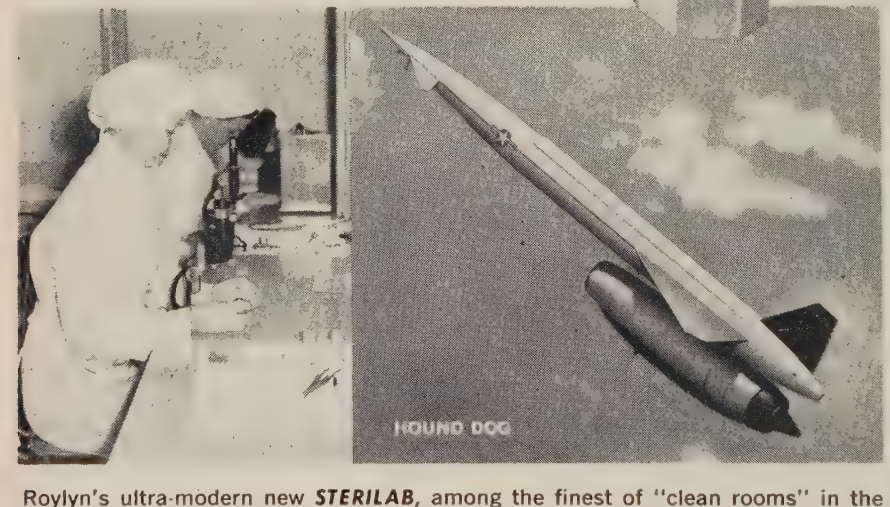

Roylyn's ultra-modern new ***STERILAB***, among the finest of "clean rooms" in the country, is now provided for assembly, testing and packaging of vital components used in the missile industry. An example is this new ultrasonically cleaned twin-mounted swivel connector which helps to keep SAC's Hound Dog flying. It is designed and qualified to MIL-J-5513A. Compact, of stainless steel, and weighing only 9 ounces, this startling new ball bearing connector operates in the engine oil system of one of America's finest missiles. Working under pressures of from 0 to 3000 psi, and at temperatures of from —65°F to 275°F, these advanced design connectors feature low rotating torque values under full operating pressures, in both pneumatic or fluid systems.

Airaterra engineering and design makes possible the adaptation of this and other swivel connectors to meet your specifications.

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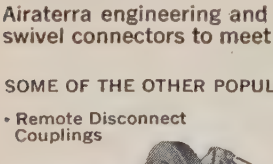

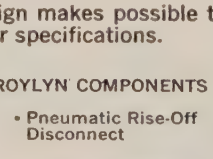

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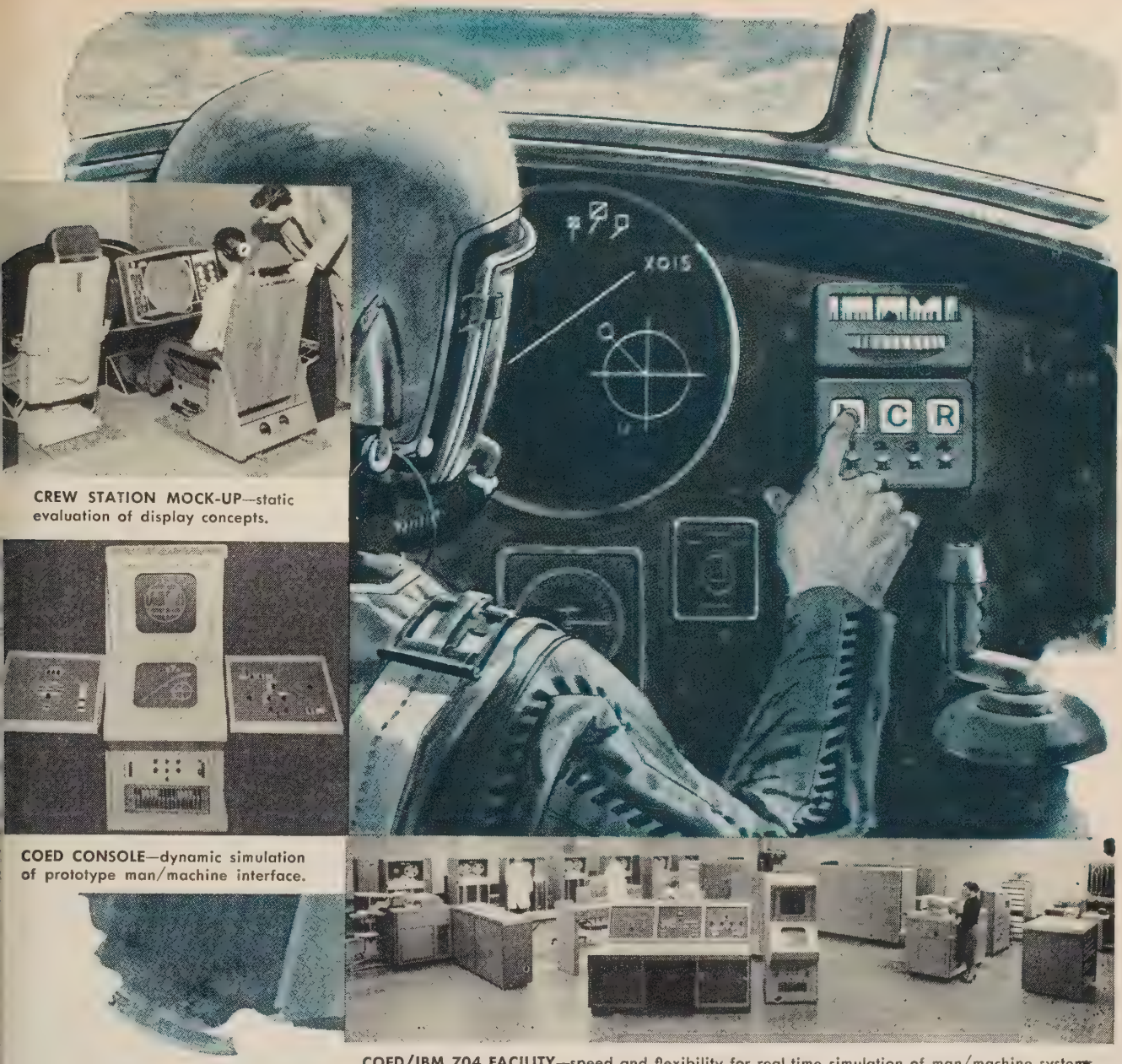
CREW STATION MOCK-UP—static evaluation of display concepts.

COED CONSOLE—dynamic simulation of prototype man/machine interface.



COED/IBM 704 FACILITY—speed and flexibility for real-time simulation of man/machine systems.

COED . . . computer operated electronic display

e airborne data processing system for the EAGLE ssile concept uses advanced digital data handling nplemented by the intelligence of the human operator. ordinated transfer of data between man and machine implemented with human-factored electronic display l control devices.

Balanced man and computer functions are assured in development of the EAGLE electronic system through alysis and experimentation with realistic operational ssions using the COED (Computer Operated Electronic splay) simulator. This simulation involves real-time grams for a large-scale digital computer which are integrated with cathode-ray-tube alpha-numeric displays and operator controls.

The COED system has been developed to provide a special facility for versatile and realistic simulations of the man-machine interface. It is a stepping stone in the Bendix program of *Intellectronics* where the ultimate goal is the machine synthesis of man's unique perceptual and intellectual faculties.

Opportunities are available to better engineers and scientists who would like to participate in this and other systems programs of the highest technical integrity.

Bendix Systems Division

ANN ARBOR, MICHIGAN

Bendix AVIATION CORPORATION

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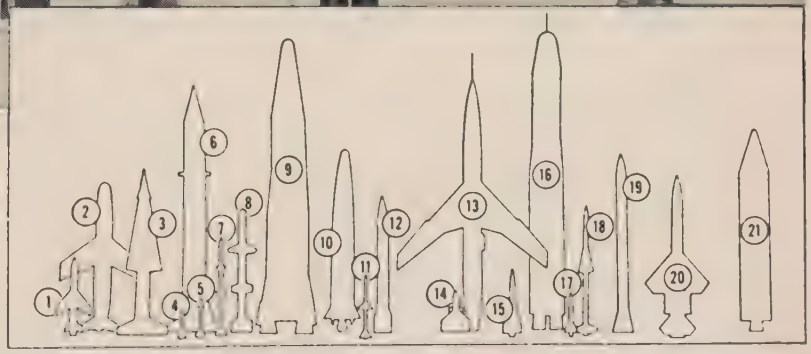
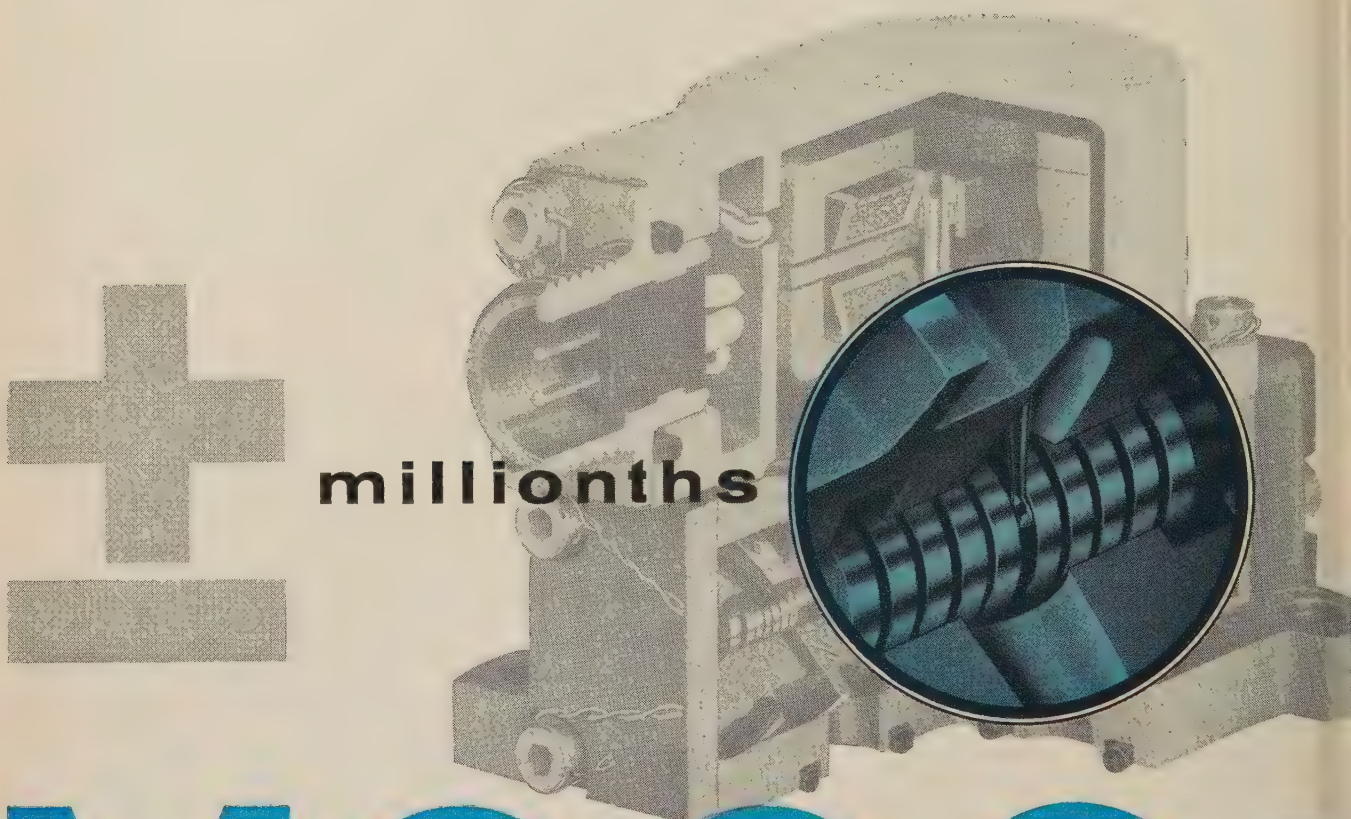
21 U.S. missiles rely on Raytheon electron tube

RAYTHEON COMPANY, WALTHAM, MASS. RAYTHEON *EXCELLENCE IN ELECTRONICS*



1. **Lacrosse.** Army. Ground-to-ground. Prime contractor: Martin.
2. **Mace.** Air Force. Ground-to-ground. Prime contractor: Martin.
3. **Nike Hercules.** Army. Ground-to-air. Prime contractor: Western Electric.
4. **Falcon.** Air Force. Air-to-air. Prime contractor: Hughes.
5. **Sidewinder (GAR-8).** Navy/Air Force. Air-to-air. Prime contractors: Philco; General Electric.
6. **Redstone.** Army. Ground-to-ground. Prime contractor: Chrysler Corp.
7. **Terrier.** Navy. Surface-to-air. Prime contractor: Convair.
8. **Talos.** Navy. Surface-to-air. Prime contractor: Bendix Aviation.
9. **Atlas.** Air Force. Ground-to-ground. Prime contractor: Convair.
10. **Thor.** Air Force. Ground-to-ground. Prime contractor: Douglas.
11. **Sparrow III.** Navy. Air-to-air. Prime contractor: Raytheon.
12. **Sergeant.** Army. Ground-to-ground. Prime contractor: Sperry Rand.
13. **Snark.** Air Force. Ground-to-ground. Prime contractor: Northrop.
14. **Quail.** Air Force. Air-to-ground. Prime contractor: McDonnell.
15. **Hawk.** Army. Ground-to-air. Prime contractor: Raytheon.
16. **Titan.** Air Force. Ground-to-ground. Prime contractor: Martin.
17. **Bullpup.** Navy. Air-to-ground. Prime contractor: Martin.
18. **Nike Ajax.** Army. Ground-to-air. Prime contractor: Western Electric.
19. **Corporal.** Army. Ground-to-ground. Prime contractors: Firestone; Gilfillan.
20. **Bomarc.** Air Force. Ground-to-air. Prime contractor: Boeing.
21. **Jupiter.** Army. Ground-to-ground. Prime contractor. Chrysler Corp.



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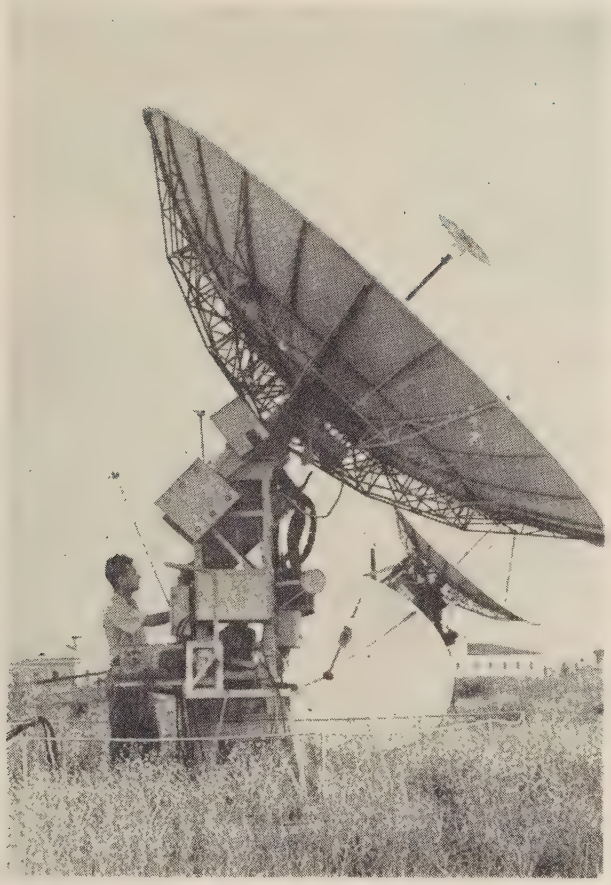


RUSSIAN radar antenna, said to be used for solar-radiation studies, probably has the narrow-beamwidth characteristics needed for tracking ICBMs.

Counterweapon systems vs the ICBM

by V. Kriksunov, Engineer-Major*

This article by a Russian engineer shows that the Reds, even in 1957, could make some pretty sound predictions about the basic anti-ICBM problems. It gives some valuable insights into the Russian approaches to radar defense and the use of on-line computers for solving intercept problems.

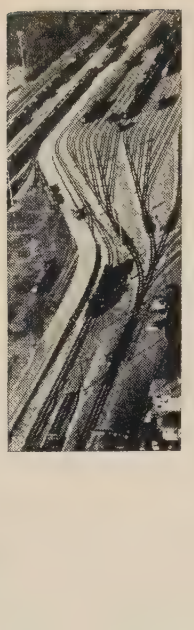
INTERCONTINENTAL ballistic missiles will follow trajectories reaching altitudes tens of times higher than the flight ceilings of modern bombers and air-breathing missiles. They will attain flight speeds of 6-7 km/sec. At first glance, the difficulties involved in detecting, intercepting, and destroying such missiles before they reach their targets appear overwhelming. But let us examine the present capabilities of missile defense and those of the near future, and see whether the picture indeed is so bleak.

We know that at present [1957] there are radar stations with detection ranges for aerial targets of up to 500 km. At the radar station, with electronic computers, missile trajectories can be calculated at these stations from only a few readings of the target coordinates. Stations operating in a continuous tracking mode can determine the ballistic missile's trajectory and predict its point of impact.

Precise detection and definition of an ICBM's coordinates may be simplified—and the detection range extended—if the missile's ionized wake is tracked. At the missile's high flight speeds, heat is produced by surface friction with the air, causing the dissociation of atmospheric gases. The result is a cloud of ionized gas particles around the

more on next page

* This is a condensation of a translation, "Intercept Problems of Intercontinental Ballistic Missiles," from *Sovietskaia Aviatsiia*, Apr. 25, '57, by W. I. Rumer, The Rand Corp., 1700 Main St., Santa Monica, Calif. S/A's editorial comments appear in brackets.



What's a big railroad supplier know about the little relays in a missile?

For 75 years, we've been building tough, reliable railroad signal equipment. Our signal relays are built to stand the rock-and-roll of high-speed trains.

We have relays that have been sitting out in the boon-docks in sub-zero and desert-hot temperatures for more than thirty years—getting only the standard two-year check up. Even after three decades, they're still making and breaking a circuit three times every second of every day.

With this experience, it was natural for us to start building miniature relays for the newborn missile age. We figured the missile people wanted a *reliable* relay. We also figured that the wee parts would make us bug-eyed. But our designers created a 6 PDT miniature relay with just three major assemblies . . . instead of a fistful of small parts.

It's a clean-looking relay. It has a minimum number of movable parts. But, a balanced rotary-type armature is its top feature. It rotates on an axis which passes through the center of gravity of the relay. This enables the relay to effectively resist applied linear acceleration forces from shock and vibration.

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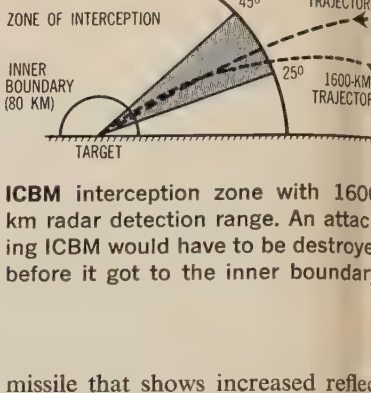

ICBM interception zone with 160(km radar detection range. An attac ing ICBM would have to be destroye before it got to the inner boundar

missile that shows increased reflec tivity for radar pulses.

A trackable wake will not exis throughout the flight trajectory bu only in the atmosphere, wher there is enough air in which t create an ionized cloud. Wak tracking could only be used at alt tudes considerably below the ape of the missile's trajectory.

The effective radius of ICBM requires that you destroy an attack ing missile at a distance of at leas 80 km from the target, accordin to estimates by foreign [Western experts. The time between the de tection of the ICBM at 500 km an the missile's arrival at a point 8 km from the target is only aroun 70-80 seconds. During this inte val, your defense system must figu out the missile's trajectory as we as the coordinates of intercept b the anti-ICBM missile, and give th command for the anti-missile ba tery to open fire.

Fire is opened at a range of 270 kilometers

To make certain that you inte cept the ICBM on the 80-km de struction borderline, you must ope fire when the missile is no less tha 270 km from its target. This leave you about 25-30 seconds in whic to solve the intercept problem.

With electronic computers, fo example, it's quite possible to solv the intercept problem within th required time. However, you woul achieve far more reliable interce tion if radar stations with a missi detection range of 1300-16000 k were set up. In this case, the inte cept zone would be extended 800 km, and you would have mo time for solving the intercept pro lem.

The process of detecting, iden fying, intercepting, and destroyin an attacking ICBM can be broke

wn into the following basic steps:
• At a distance of, say, 8000
, an ICBM is launched from an
derground platform. It rises up-
rd and then pitches forward until
longitudinal axis forms an angle
43 deg with the horizon.
• After acceleration to the speed
eded for the prescribed range,
second-stage rocket cuts off.
e ICBM goes into its trajectory,
aching an altitude of 1270 km at
peak of its elliptical trajectory,
er which it begins its free fall
earth.
• A few seconds later, the
BM penetrates the defensive
dar station's detection boundary
a distance of about 500 km from
target area. The radar locks on
d starts to track.
• After several seconds, the
dar station has computed the ap-
oximate trajectory of the missile.
e long-range detection system
oduces two groups of data: one
the anti-ICBM missile battery
d the other for launch-position-
; the ICBMs kept in combat
diness for counter-attack against
enemy's missile bases and other
al targets.
• At the radar station, an elec-
nic computer corrects the cal-
ated trajectory and determines
coordinates of the intercept
nt. These data are fed continu-
sly to the anti-missile launch-
trol center.
• At the proper moment—de-
mined by the computer—the
nmand to fire counterweapons
given, and these weapons are
nmitted.

e detection accuracy is per cent

n the [Soviet?] press it has been
ed that, if the long range radar
ection station has an operational
ge of 1600 km, the distance to
incoming ICBM will be deter-
ned to within one per cent of
ge, or 16 km. Naturally, if the
ial range figure is inaccurate,
calculation of the intercept by
computer will be inaccurate,
Under the circumstances, what
hods can we use to insure the
truction of attacking ICBMs,
how successful are they likely
be?
Ve can assume that you can use
anti-ICBM with a 20-kiloton
nic warhead. This counterwea-
could do an effective job on an
BM through the effects of either

more on next page

What can you do with a remarkable instrument like this?

We knew we had an outstanding instrument in our product line when this readout device was introduced several years ago. It proved to be ahead of its time during those early days, but now this remarkable precision instrument for displaying data is gaining acceptance in many industries. It's about as big as a candy bar, and it will display, store, or transfer up to 64 different numbers, letters, or symbols without using complicated conversion equipment and "black boxes."

This is an entirely new species of readout device so we had to give it a new name, the Readall* readout instrument.

We developed the Readall instrument for data display in flight control equipment. We knew the Readall instrument was fine but didn't know just *how* valuable it was. But one of our engineers did. He designed a complete new pipeline control system based on the new instrument. The application was a breakthrough in data handling, and the control system is a big success.

Naturally, we put the Readall instrument on the market so systems engineers could use it to improve their control systems. We announced the Readall instrument as ". . . an electro-mechanical, D.C. operated, read-out device for displaying characters in accordance with a pre-determined binary code . . . a compact, self-contained device . . . which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed."

Other systems have been developed with separate units for data display, decoding, storing, and electrical readout. These separate units cost more and occupy more room. Market response confirms the need for *one*, *small*, inexpensive unit that does all three jobs. The Readall instrument serves the purpose.

We'd like to discuss possible applications for the Readall instrument with you. If you want information as to possible applications you have in mind for this remarkable instrument, please fill in the coupon.

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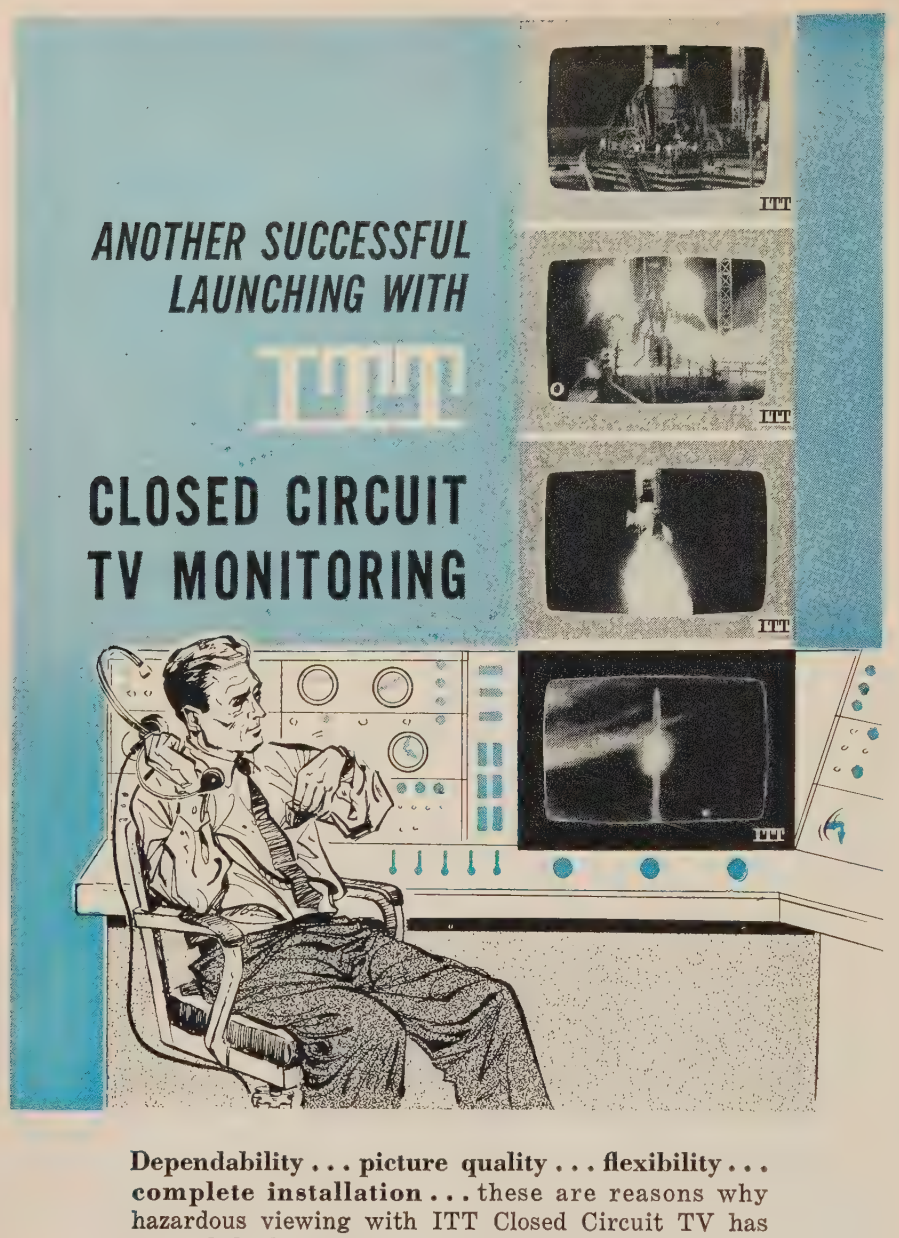

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With an ITT system, you get perfect performance under all operating conditions. The picture is sharp and clear, with 700 line resolution. The camera—designed for missile monitoring—withstands noise, shock, vibration and compensates for light changes as extreme as 10,000 to 1.

This compact closed circuit system is easily, economically installed anywhere, using standard cables and a variety of quick-adapting accessories. And ITT's turnkey systems include design, installation, training of operating personnel and complete on-site maintenance.

For military or industrial application, let us prove to you how simple, economical and reliable closed circuit monitoring is with an ITT system. For complete information, contact your local ITT Closed Circuit TV representative or write us for Data File SA-1037-1.

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the blast wave or the thermal and nuclear radiation created by its exploding warhead.

To achieve the necessary blast-wave effects with a 20-kiloton warhead, the counterweapon must intercept the ICBM with an accuracy of no less than 300 m. If the intercept occurs at high altitudes, where the air density is very low, the blast wave's effectiveness is noticeably weaker, and the intercept accuracy therefore must be even greater.

If the anti-ICBM is to carry a warhead of sufficient weight and impart to it the necessary speed, its launch weight and thrust must be close to those of the attacking ICBM. Theoretical computations for a three-stage anti-ICBM show that, for a third-stage weight of 450 kg and a powered flight time on the order of 30 seconds, a launch weight of 45,400 kg and a thrust of about 140,000 kg are needed.

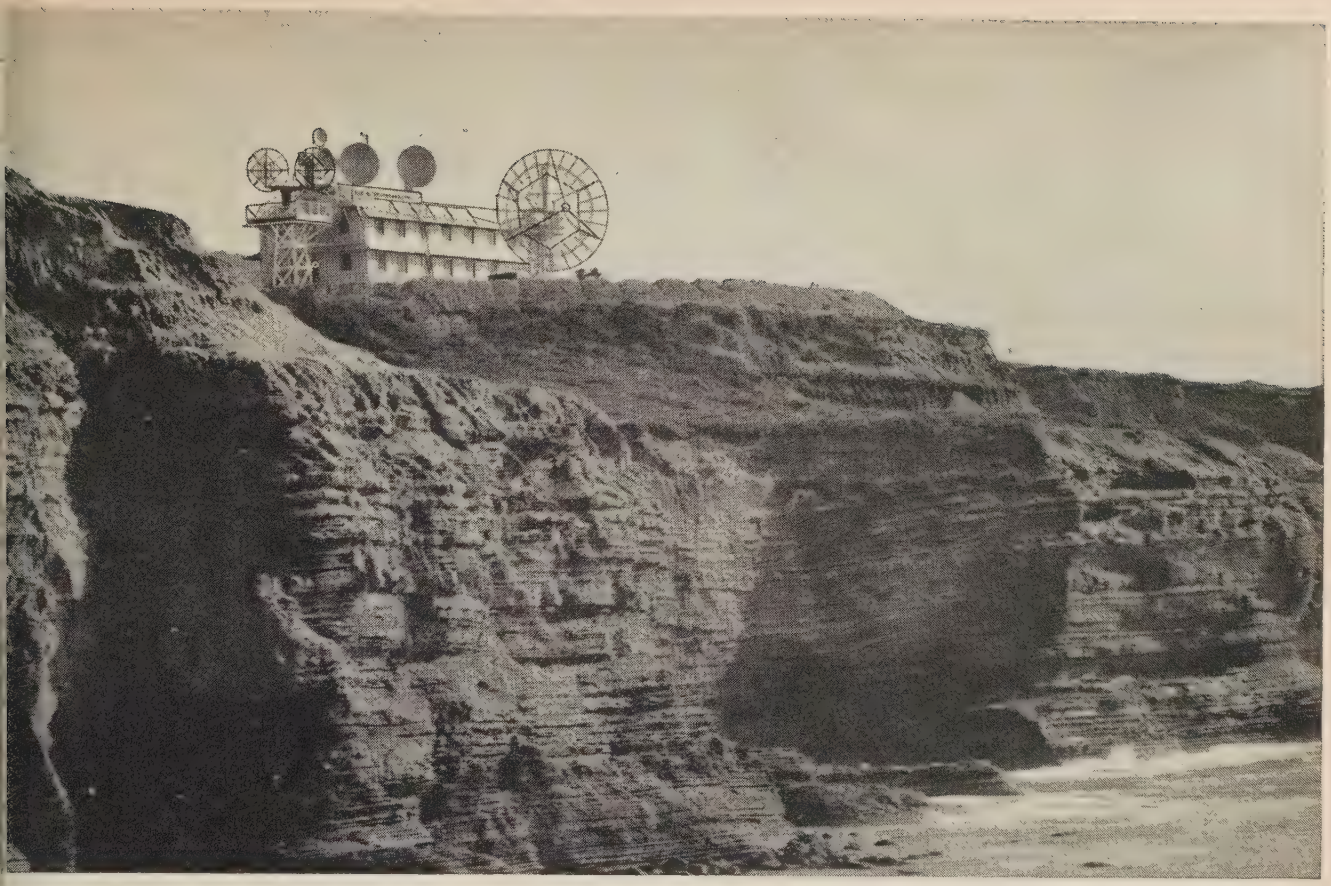
For a simpler solution of the interception problem, [Soviet ?] military experts believe that the aiming accuracy of the counterweapon must be improved. Improvements could be achieved in two ways: (1) by intercepting the attacking ICBM closer to the target or (2) by equipping the anti-ICBM with radar homing systems. We can assume that an infrared homing head would be feasible

Foreign [Western] military experts attach great importance to the development of ICBMs with extremely powerful warheads. However, many experts do not consider these missiles to be the "absolute weapon," since a powerful anti-ICBM missile defense system is technically fully feasible.—End

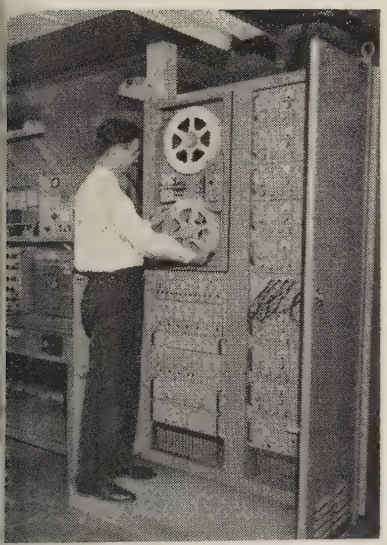
Dredging for ASW

Sonar test basin under construction at Sperry will be about 400 ft long, 200 ft wide, and 25 ft deep (see *S/A Engineering Intelligence, p. 34, Feb '60*). Aiming at the simulation of the ocean environment for tests of ASW detection devices, Sperry is dredging a basin rather than building a conventional test tank. A 17x29-ft floating barge will be used to extend test sensors into the water.

Both acoustic and non-acoustic detection methods for locating anti-ship mines, torpedoes, and subs will be studied in its "private sea," says Sperry.



NAVY USES HONEYWELL SYSTEM TO "CATCH" TV SIGNALS BOUNCED OFF TROPOSPHERE



(Official U. S. Navy photographs)

To determine the effects of frequency, distance, antenna size and scatter angle on TV and other wide-band transmission by means of tropospheric scatter links, the U. S. Navy Electronics Laboratory in San Diego, is using a 14-channel Honeywell Series 3170 Magnetic Tape System to record this valuable data.

Microwave propagation paths of 90 and 190 miles and frequencies of 1300, 3400 and 9400 megacycles are used for these studies. Peak values are recorded on magnetic tape as signals varying between 0 to 100 cps. The frequency of this signal represents the fading rate of the incoming microwave signal.

The recorded data can be played back to determine power spectrum, amplitude distribution and median signal level. The simplified speed control of the Honeywell system makes it easy to slow down the data for analog computation and digital analysis.

The unique features of the Honeywell Series 3170 System can also provide an efficient solution to your data recording problem. For the full story on a system tailored to your needs, just give your Honeywell field engineer a call. MINNEAPOLIS-HONEYWELL, 10721 Hanna Street, Beltsville, Md.

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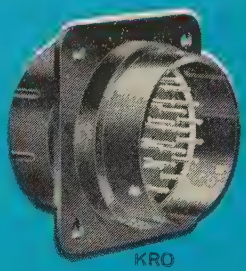
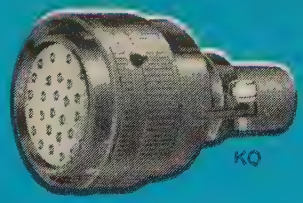
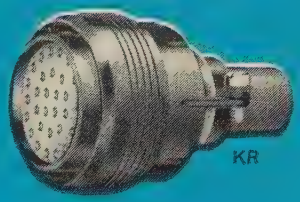




• VIBRATION PROOF • SHOCK RESISTANT



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CANNON PLUGS

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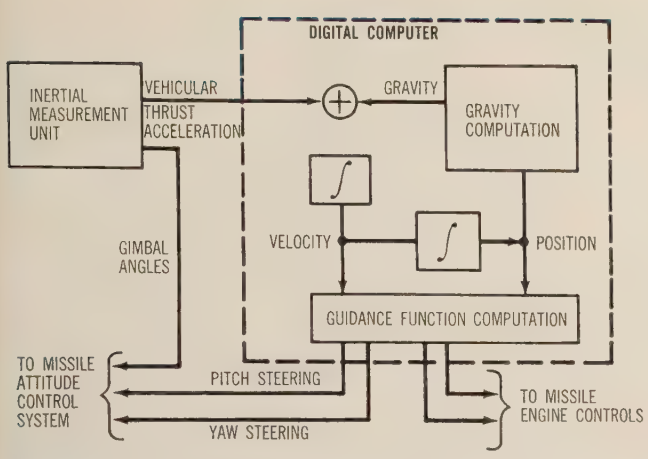
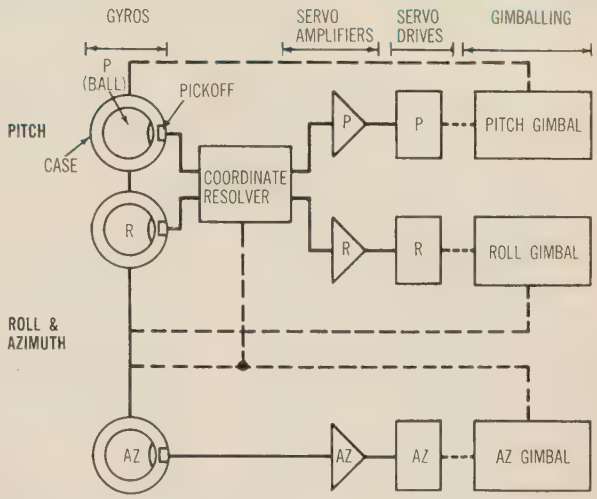


FIGURE 1: Flow diagram of the pure-analytic type of inertial guidance system.



GIMBAL servo loops (shown in simplified fashion) for an inertial guidance system.

The pure-analytic approach to inertial guidance design

This is the first article in a two-part series on the design of an inertial guidance system by the pure-analytic approach and covers the inertial platform. The second article will analyze the system's digital computer.

THE pure analytic, or non-level, approach to inertial guidance system design involves a system made up of the two usual major IG units: an inertial platform with its control electronics and a digital computer. Since this method puts the burden of the mathematical operations on the computer, the platform is physically and electrically different from other platforms that must both sense and compute.

Basically, the platform is an assembly of two-degree-of-freedom gyros and mutually orthogonal accelerometers that are kept aligned with a fixed reference in space. Variations in the position of the vehicle are determined through computer operations on the accelerometer outputs—correcting for gravity and then singly and doubly integrating with respect to time to get speed and distance traveled from a known starting point. The results obtained in the computer are transmitted to the control system as attitude commands (*Fig. 1*).

The inertial platform must be critically aligned before launch to terrestrial reference coordinates. This requirement is met by aligning the coordinate system axes with the local vertical by means of pendulums or accelerometers and with the azimuth or true bearing by means of an optical link. After launch, these initial coordinates become the inertial coordinates, space-stabilized with respect to a gyro-controlled gimbal system.

You begin the platform design by analyzing the specs for the entire guidance system to determine the functional requirements—including the error allotments for each major part. Naturally, these allotments must be based on what is practically feasible in terms of design techniques and hardware. After the preliminary design study, you re-examine your error allotments to see how much you can tighten up on tolerances to insure

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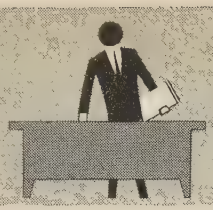

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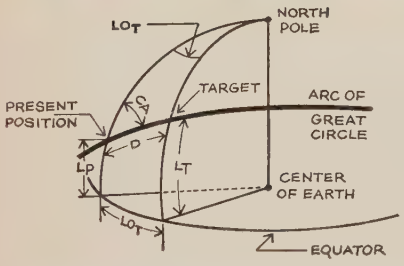
As a result of Eclipse-Pioneer's experience in utilizing resolver chains in its navigational systems, considerable data has been compiled which may be helpful in solving your problems. Write us today for complete information.

TYPICAL PROBLEM



PROBLEM: Design a computer to provide an aircraft with continuous bearing and range information along the arc of a great circle.

C_A—Bearing

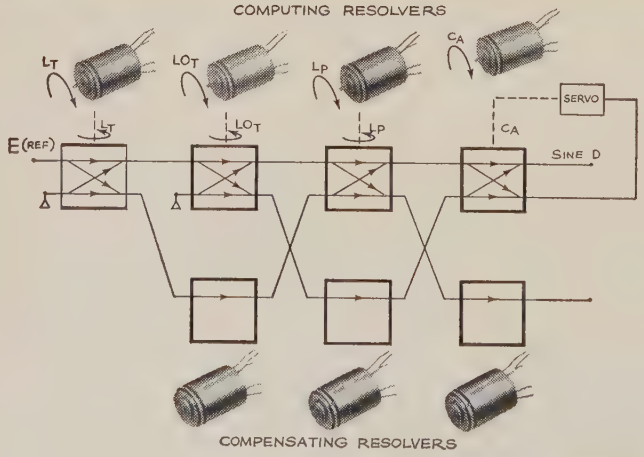
LO_T—△Longitude measured from present position to target

L_P—Latitude of present position

L_T—Latitude of target

D—Great Circle distance from present position to target.

SOLUTION



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high reliability, improve producibility, and keep costs down.

These procedures naturally lead to the preparation of functional schematic and mechanical system diagrams, and these give you a chance to study how you can simplify your design through logical placement of components. You'll find you are almost forced to minimize the number of internal interconnections between subassemblies —an important step toward miniaturization.

Gimbal system isolates the stable platform

The gimbaling system isolates the stabilized platform from the forces of the vehicle's rotational motion. The gimbals pivot within each other about the three system-coordinate axes. Their relative motion is imparted through servos that are built into the gimbal structures to minimize size as much as possible.

Before you start designing the platform-gimbal structure, you must study the operating load conditions. Environmental conditions, vibration, and sustained acceleration forces have the most significant effects.

As you know the missile attack angles along the expected trajectory (established during the early design stages), you can figure out the components of the vehicle thrust acceleration forces acting along each of the platform gimbal axes. With these data, you can set up realistic design parameters. Once these are established, the emphasis in designing the actual structures is on determining the dynamic response characteristics of the gimbal housing and gimbal-pivot assembly as they affect the performance of the inertial components and servos.

A good approach is to determine the interrelationship of such platform parameters as mass, component resonances, gimbal and housing stiffness, bearing and servo compliance, and the transmissibility of the vibration-isolation system. Structural design criteria for performance under sustained acceleration and resonant response to vibration or acoustic energy inputs are based on:

- the allowable misalignment between the accelerometer coordinate axes and the stabilized plane established by the gyro spin axes

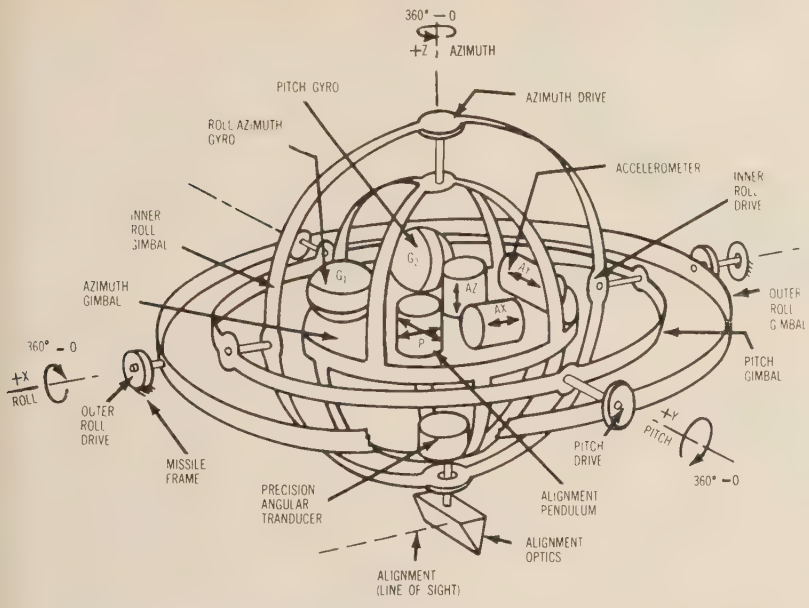

FIGURE 2: Electromechanical design of the inertial platform.

(from which the amount of azimuth gimbal stiffness is determined);

- acceptable levels of imbalance torque loads due to sustained longitudinal thrust and laterial maneuvering accelerations;
- rotational compliance of the vibration-isolation system and torsional compliance of the gimbal servo;
- increased friction torque loads under high-g acceleration;
- structural resonance limits for the platform assembly that will protect critical inertial components;
- filtering out excessive input vibration energy levels in the vibration-isolation system and gimbal structure to reduce gyro drift and accelerometer errors.

Some of these design considerations require special analysis before you can firm up the design layout and physical constants. For example, the misalignment of the accelerometer coordinate axes with respect to the stabilized plane must be studied as a function of both the rigidity and the long-term dimensional stability of the azimuth gimbal. If the system structures are isoelastic (the ideal case), the dynamic mass imbalance torques seen by each gimbal servo are zero. However, isoelastic structures don't always lend themselves to efficient design, so you also have to look into the possibilities of using anisoelastic structures.

The mass and stiffness of the gimbals are primary factors in determining the imbalance torque. The ratio of gimbal stiffness in the primary load directions governs the mass imbalance. As this ratio approaches unity, the smaller becomes the imbalance torque produced in a multi-directional acceleration field.

Vibration frequencies over a broad range

In the missile's operating environment, the equipment is subjected to a broad range of vibration frequencies. Ideally the platform has no structural resonances in the gimbals or components up to about 1000 cps, but actually this condition can't be achieved. You must, therefore, approach the design as follows:

- determine the resonant frequency spectrum of each critical component (e.g., gyros and accelerometers);
- determine the structural resonances of the platform;
- formulate a mathematical analog of the system from the missile frame to the azimuth gimbal (computing such lumped system parameters as mass distribution, gimbal stiffness, bearing compliance, and damping constants);
- write the equations for this multi-degree-of-freedom system for solution on an analog computer;
- run a vibration-frequency

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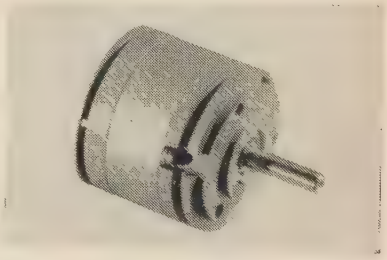
GEAR HEADS

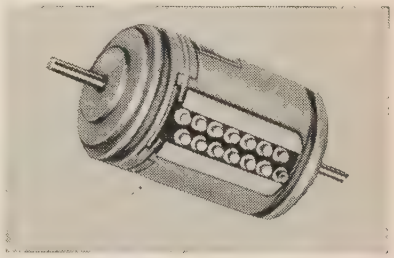
Compact units that provide output motor speed reductions.



These easily detachable heads are available in various frame sizes, and supply reductions in ratios ranging from 7.22:1 to 42,471.90:1. Ball bearings are Class A. B. E. C. 5, or better, and gears are cut to AGMA Precision II tolerances, or better, with backlash held to 30 minutes, or better. Adaptable to variety of motors and motor generators. Write for details.

CODED COMMUTATORS

Shaft position-to-digital converters in miniature.



For use with digital control systems, data processing equipment, or computers, these small devices convert analog information to binary digital form. Size particularly suits them to airborne applications. Unit shown consists of 7-digit converter utilizing linear, doublebrush, natural binary code. Each track brush is split for better contact. Unambiguous output giving shaft resolution to 1 part in 128 can be provided. Ask for details on the many models available.

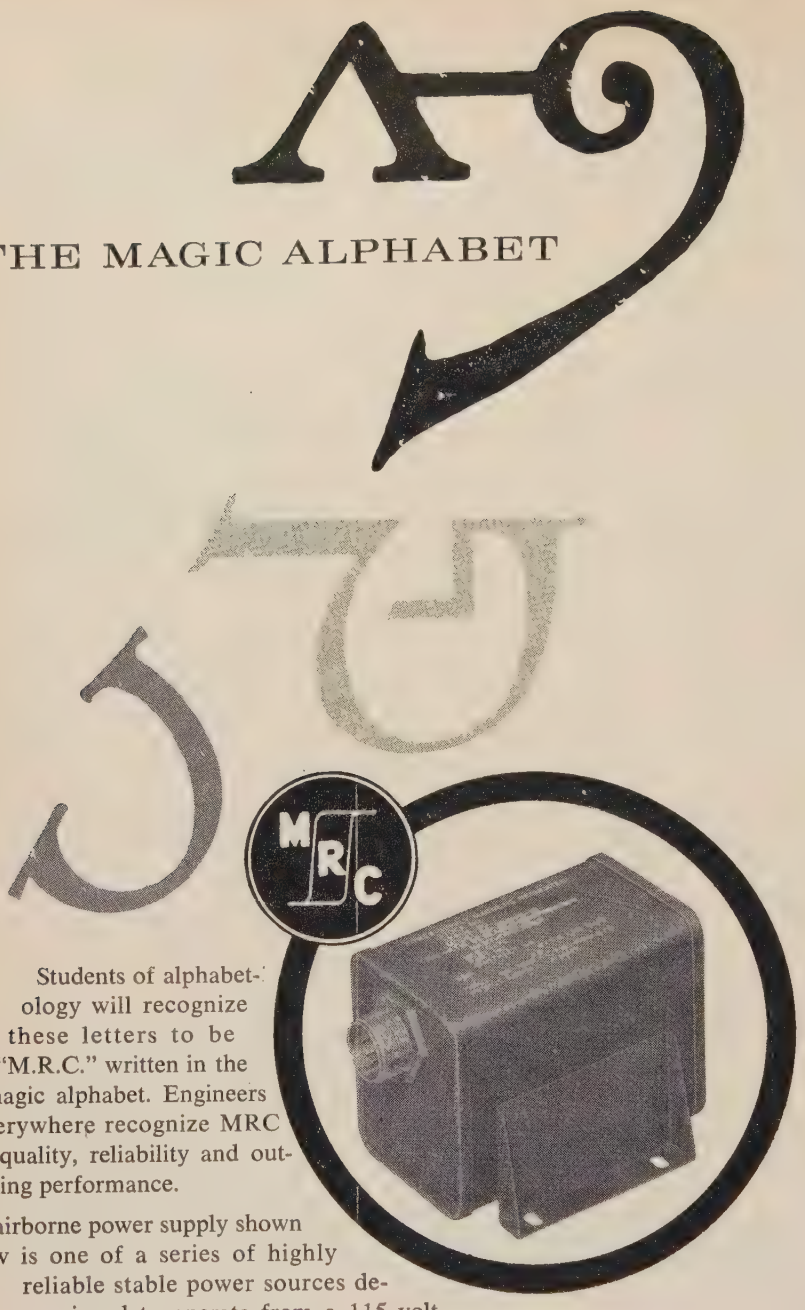
Manufacturers of
GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
PACKAGED COMPONENTS

Eclipse-Pioneer Division

Bendix
AVIATION CORPORATION
Teterboro, N. J.

Write in No. 156 on Reader Service Card

THE MAGIC ALPHABET



Students of alphabetology will recognize these letters to be "M.R.C." written in the magic alphabet. Engineers everywhere recognize MRC for quality, reliability and outstanding performance.

The airborne power supply shown below is one of a series of highly reliable stable power sources designed to operate from a 115 volt, 400 cycle line and supply well regulated and filtered DC power. Dual magnetic regulation, an exclusive feature of this series, supresses line transients and compensates for changes in load.

The use of magnetic amplifier circuitry with tantalum capacitors, silicon diodes and rectifiers...coupled with inherent short circuit protection...combine to achieve a degree of reliability unattainable in other types of circuits.

SPECIFICATIONS:

Model 40-103-0 is a typical 5 watt supply used extensively in missile instrumentation:

Input / 95-125 V; 380-420 cps
Output / 4.75 to 5.25 V DC (Adjustable), 0 to 1 amp
Regulation / ±0.1%
Ripple / 0.5% rms max. at full load

For additional information on MRC's complete line of airborne power supplies, write for Data File PS 1000.

MAGNETIC RESEARCH CORPORATION
3160 West El Segundo Boulevard, Hawthorne, California
Write in No. 157 on Reader Service Card at start of Product Preview Section

spectrum analysis on the computer and find the system transmissibility characteristic.

Now you have enough information to begin the design and packaging of the platform gimbal system. Considering the importance of the weight factor, you have to allow for its control even in the design layouts.

As we've noted, the platform must be mounted in a gimbal system with an angular freedom greater than the rotational motion of the vehicle. If the bearings were absolutely frictionless, no maneuver of the missile would disturb the position orientation of the platform. However, since bearing friction can't be cut to zero, friction torques tend to displace the platform from its stabilized position. To overcome these torques and those due to cable and system imbalance, gimbal servo drives are introduced at each pivot axis.

Any disturbance that tends to move the coordinate axes of the system relative to the gyro-stabilized reference also moves the gyro cases. Any relative motion of gyro case to gyro ball is sensed by the gyro pickoffs, whose signal to the gimbal servo amplifiers causes the gimbal servo motors to rotate the gimbals—and so the gyro cases—back to the original positions (*Fig. 2*).

Dynamic system performance and stability criteria are found from the solutions of servo torque equations that take into account all of the system design parameters. In this way you get the transmissibility ratio (or closed-loop frequency response of the gimbal servos for a rotational input to the missile), which is used for measuring the dynamic performance of the servo. The resultant gimbal torques and static error are the other important characteristics. Each of the two servo motors making up a servo drive operates a separate gear train whose output drives the appropriate gimbal to compensate for position deviations sensed by the gyros. With two motors, there can be no backlash in the servo gear train, and you can use non-precision gearing. The motors are biased with small opposing torques to take up the backlash. When the error output of the servo amplifier produces a corresponding net torque at the output of the servo system, the gimbal moves accordingly. Servo

damping is done by a network damping system that is part of the servo amplifier.

To give your unit long life and high accuracy, you must base the absolute air and structure temperatures of the platform on the design characteristics of the gyros and accelerometers. Both pre-launch and in-flight thermal environments should be considered in choosing the measures for temperature stabilization.

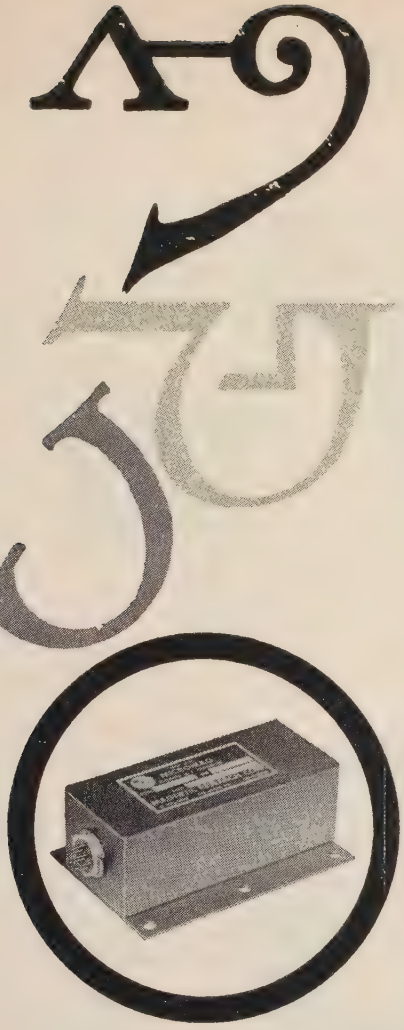
Gyro drift characteristics are affected by the temperature variations between the buoyant and actual temperatures of the gyro fluid. Therefore, you have to control the absolute air temperature that envelops the gyros to within a few degrees of the desired fluid temperature. Important factors in the platform's thermal environment are the heat generated by the components and its dissipation rate, the overall system heat transfer coefficient, and the heat in the guidance system enclosure both before and after launch. Also, you must take into account the conditions under which the platform is operated in lab and factory areas for system and missile checkout.

The actual electric design you begin by preparing a system schematic based on the functional requirements. Then the design must be reviewed—your aim must be maximum simplicity with the minimum of circuit components and interconnections. Naturally, you will want to keep as many functions as possible in the ground equipment to save weight on the airborne portion.

Logical location for each element is found

Such an approach almost automatically yields a logical location for each element and establishes a good basis for the preparation of engineering design layouts. In these, the prime emphasis is on physically locating the components so that they are easy to assemble, test, and maintain.

You'll find that you get platform size and weight by building many of the electric and electronic components into the gimbal system. Just where you should put a particular component depends on the local environmental conditions, the possible savings in passing wire through flexes or slip rings, and the space you have available.—**BK**



MRC proudly presents another series of quality products equally recognized for dependability, and performance. The Micromag, a low-level drift-free magnetic DC amplifier, completely solid state...ideally suited for instrumentation applications where temperature, strain and pressure are to be measured. DC signals in the millivolt region are amplified to the 0 to 5 volts DC range required for telemetering and recording systems.

Typical Specifications:

Power / 26-31 volts DC, 10 milliamps
Input Signal / 0-10 millivolts DC
Voltage Gain / 500 ±10%
Output Load / 100 K ohms
Linearity / ±2%
Gain Stability / ±3% from 0°C to +65°C
Common Mode Rejection / At DC, 10^6
At 60 cps, 10^4
At 400 cps, 10^3

For additional information on MRC's complete line of Micromags, write for Data File No. MA1001.

MRC

MAGNETIC RESEARCH CORP.
3160 West El Segundo Blvd.
Hawthorne, California
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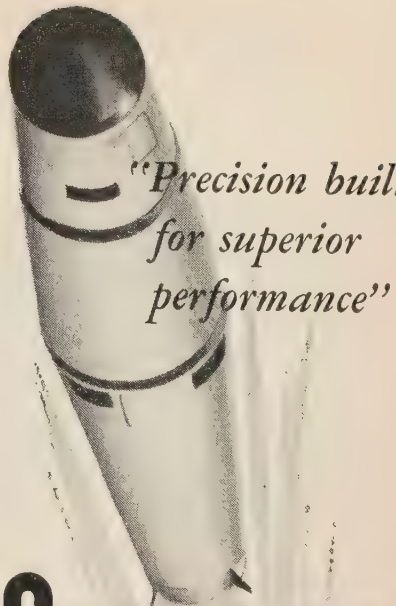
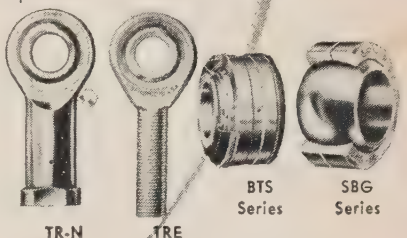


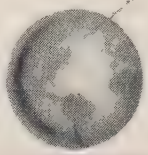
"Precision built for superior performance"

SPHERCO
BEARINGS & ROD ENDS

AVAILABLE IN A COMPLETE RANGE OF SIZES

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.





WRITE FOR BULLETIN 257

SPHERCO
A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
2 RIDGEWAY AVE. • AURORA, ILL.
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600° to 1000° F.

HIGH STRENGTH AND STABILITY

WITH GOOD FABRICATION PROPERTIES

AM 350 and AM 355 are metals for the space age! The combination of easy fabrication with high strength-to-weight ratio of AM 350 and AM 355 interests missile and supersonic aircraft designers with problems of high strength at elevated temperatures.

This pair of precipitation hardening stainless steels from Allegheny Ludlum research are easy to fabricate in the annealed condition. They can be spun, drawn, formed, machined, brazed and welded using normal stainless procedures.

Both alloys have high strength without embrittlement from room temperature to 1000°F, plus good ductility at elevated temperatures. They have remarkable stability and excellent corrosion resistance.

AM 350 is available in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355," **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.**

022

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Write in No. 159 on Reader Service Card at start of Product Preview Section

SAGE air defense system, despite the billions we've poured into it, remains a gigantic question mark. How effective it would be against an actual air attack can only be predicted theoretically. Many in industry and the military believe that, if the entire system were turned on, the interactions and interference caused by radiating elements in the system would make certain parts of Sage useless, leaving wide gaps in our air defense net. A dry run to evaluate Sage probably would require all TV and radio stations, certain air and sea navaids, and non-military air- and shipborne radars to go off the air during test.

ELECTRONIC countermeasure using X-rays is being worked on by Aeronutronics. Reportedly it is intended to counter inertial guidance systems.

COOLING handbook for ground electronics published by Rome (N. Y.) Air Development Center is the best compendium in its field we've seen to date. It is available from Astia under the title "Handbook of Methods of Cooling Air Force Ground Electronics Equipment (AD-148907)".

GE LIGHT MILITARY'S Advanced Research Center in Ithaca, N. Y., has been trying to get a monkey to "fly" a simulated space vehicle in response to video displays. They are having trouble persuading the monkey to think more of space flight and less of bananas, says GE researchers.

ELECTRONIC Industries Association figures some 39 per cent of the total defense hardware budget for fiscal '60 is going for electronics. For space flight, it foresees the use of electronics in three major areas:

- design and fabrication of the payload;
- data acquisition, reduction, and transmission;
- guidance and control of boosters.

EIA forecasts that electronics cut of the space dollars should rise over the next decade from 20 per cent to something over 40 per cent. In dollars: some $77 million in fiscal '59, an expected $814 million in '70.

GROUND NAVAIDS, communications and air traffic control systems and equipment will continue to grow as an electronics market area, predict EIA's statisticians. The electronic portion of FAA's budget is estimated at $88.8 million for fiscal '60. Its increase has been charted by EIA through '70:

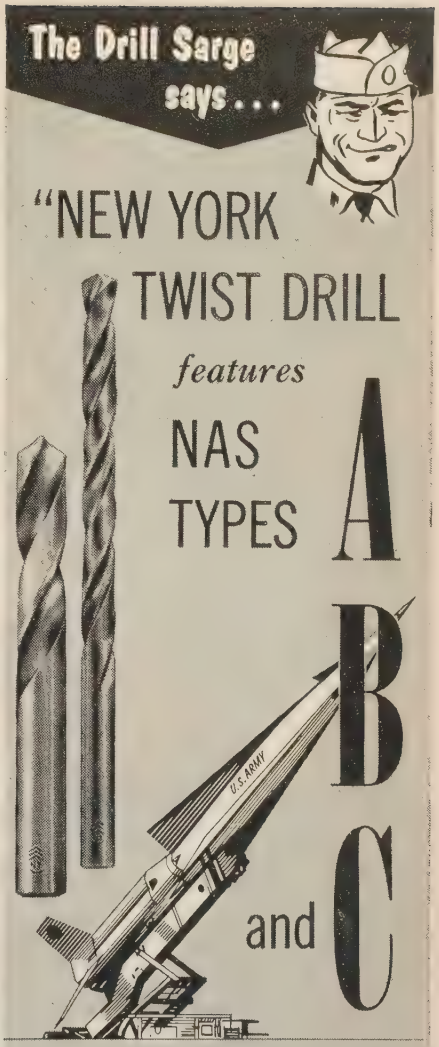
'61	$99.4 million
'62	$108 million
'63	$116 million
'64	$124 million
'65	$139 million
'66	$155 million
'67	$164 million
'68	$174 million
'69	$179 million
'70	$184 million

FOR GENERAL aviation (private and business aircraft), EIA estimates the potential electronics market at some $20.8 million a year now. By '70, the figure will be about $32.4 million, it's predicted.

MISSILE electronics spending by Dept. of Defense will top aircraft electronics in Dept. of Defense spending in fiscal '60: $1750 million for missile electronics (which is 32.7 per cent of the DOD electronics dollars), $1700 million for aircraft electronic (3.17 per cent of all DOD electronics spending).

As more electronics dollars go into missiles, we should see more shifts in the relative standing of aerospace electronics companies. Some straight "airplane electronic" companies that never got too interested in the missile market are now searching for ways of cracking this "new field". The big difference, of course, between aircraft and missile electronics work is the higher percentage of R&D and the lower percentage of production in the latter. A company without a strong R&D capability has little chance of survival.

NASA'S Goddard Space Flight Center awarded ACF Industries' Avion Div. a contract for engineering, lab, and model shop work on ultra-precise printed circuits under the "quick reaction" concept. Normal procurement procedures will be waived on this contract to get the work done in very little time.



Meeting the strict specifications of National Aircraft Standards, New York's Type A, B and C twist drills are specially designed for heavy duty drilling. Their sturdy construction and precision points last longer and give greater production ...Best of all, you pay no premium for these special types.

Other special heavy duty drills featured in the New York line are made for drilling heat hardened aluminums, 75ST, Titanium, Inconel X, 17-7, 19-9 and other tough and abrasive alloys. They bite in clean and easily, giving more holes, all perfectly round and on size.

Remember, New York saves money on your twist drill bill and you get top quality work every time! If you wish further information, one of our sales engineers will be glad to call on you.

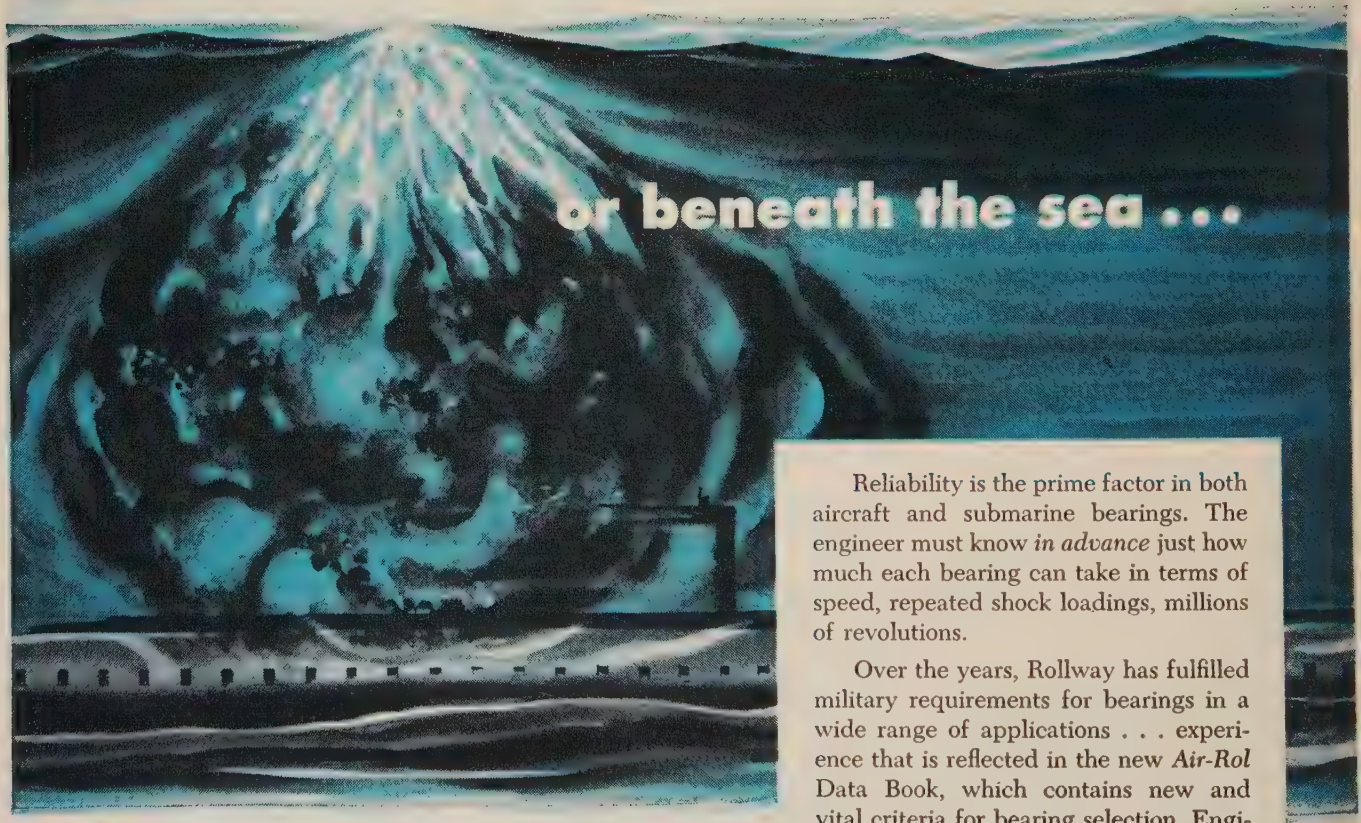
NY

NEW YORK TWIST DRILL COMPANY, INC.

278 Lafayette Street, New York 12, N.Y.

MIDWEST OFFICE:
30-A N. Clinton St., Chicago 6

WESTERN OFFICE:
3537-A E. Olympic Blvd., Los Angeles 23



Reliability is the prime factor in both aircraft and submarine bearings. The engineer must know *in advance* just how much each bearing can take in terms of speed, repeated shock loadings, millions of revolutions.

Over the years, Rollway has fulfilled military requirements for bearings in a wide range of applications . . . experience that is reflected in the new *Air-Rol* Data Book, which contains new and vital criteria for bearing selection. Engineers may obtain it by writing on company stationery to Rollway Bearing Company, Inc., Syracuse, N. Y.

ROLLWAY®

Air-Rol®

BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • LosAngeles • SanFrancisco

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space/aeronautics

CONFIDENTIAL

March 1960
(good until 5/15/60)

Employment Inquiry Form

(Not an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

- ☐ AiResearch Mfg. Co. 172
- ☐ Avco Corporation; Crosley Div. 172
- ☐ Bendix-Pacific 168, 200
- ☐ Convair Astronautics Engrg. Div. 253
- ☐ Garrett Corp. 172
- ☐ Guided Missiles Range Div.; PanAm Airways, Inc. 285
- ☐ Johns Hopkins University; Applied Physics Lab. 171
- ☐ Lockheed Aircraft Corp. 183
- ☐ Martin Co., The; Denver Div. 69
- ☐ Minneapolis-Honeywell Regulator Co.; Aeronautical Div. 248, 249, 251
- ☐ Pan American Airways, Inc.; Guided Missiles Range Div. 285
- ☐ RCA, Camden Engrg. Div. 170
- ☐ Raytheon Mfg. Co. 214
- ☐ Republic Aviation Corp. 168
- ☐ Rohr Aircraft Corp. 76
- ☐ Space Technology Labs. 27
- ☐ System Development Corp. 169
- ☐ Vitro Weapons Services 170
- ☐ Westinghouse Electric Corp.; Baltimore Div. 167

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

space/aeronautics

CONFIDENTIAL

March 1960
(good until 5/15/60)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

Westinghouse-Baltimore has a radar story to tell you. For a meaningful engineering career, you owe it to yourself to know what the Baltimore Divisions of Westinghouse are doing . . . and how you might participate in exciting programs now under way. We welcome the opportunity to give you the facts . . . and let you judge for yourself. If you are an experienced engineer, learn about our advanced development of new weapons systems involving revolutionary data processing, antenna systems, and system synchronization. These offer immediate career opportunities for both electrical and mechanical engineers with experience or interest **in the following fields:**

Molecular Electronics
Microwave Systems
Advanced Antenna Systems
Liaison and Field Engineering
Transmitter and Receiver System Development
System Synchronization
Digital Computer Design
Advanced Data Displays
Systems Reliability Prediction
Advanced Systems Automated Test
Mechanical Design & Packaging

New York Interviews

While attending the I. R. E. Show, be sure to visit us at the Convention Hotel, or call MUrray Hill 8-0163.

Send resume to: Mr. A. M. Johnston, Dept. 263

Westinghouse

BALTIMORE

P. O. Box 746 Baltimore 3, Maryland

AIR ARM • ELECTRONICS • ORDNANCE

Check Employment Inquiry Form on Page 165

BENDIX-PACIFIC

in Southern California

needs ENGINEERS *with*

DOCTORS'-MASTERS'-BACHELORS'

DEGREES

for electrical, mechanical and systems work in fields of Instrumentation—Telemetry

Anti-Submarine Detection Systems/Operations Research

Missile and Aircraft Fluid Controls.

Please send resume to MR. W. C. WALKER,
ENGINEERING EMPLOYMENT MGR.

Other High-Level Electronic
Engineering Positions Available

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION
NORTH HOLLYWOOD, CALIFORNIA

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New Gateway to Achievement in Astronautics and Aeronautics

Republic Aviation's *New* Research & Development Center

Engineers and scientists whose minds are challenged by unsolved problems across the entire spectrum of technologies concerned with space exploration and upper atmosphere flight, are invited to inquire about the exceptional facilities for both theoretical and experimental investigations provided by Republic's new Research and Development Center (scheduled to open Spring 1960).

Senior level openings exist in the following areas:

Space Electronics *(Guidance, Navigation, Communications)* / Hydromagnetics / Advanced Computer Technology / Applied Mathematics / Nuclear Power Packages / Space Environmental Studies *(Life Science)* / Celestial Mechanics / Hypersonics / Electronic Theory / Plasma Physics / Radiation Studies / Re-entry Techniques / Materials Research & Development / Fluid Mechanics

Please forward resumes to: Mr. George R. Hickman
Technical Employment Manager, Dept. 6C.

REPUBLIC AVIATION
Farmingdale, Long Island, New York

Check Employment Inquiry Form on Page 165

IMPORTANT

In filling out Employment Inquiry Form be sure to print clearly. If you check more than one company on the form it must be photostated in order that each company receives a copy.

PROPER PROCESSING DEMANDS LEGIBILITY

Analytical Engineers:

Want to see the whole picture?

Some engineers are content to stay in their own technological backyards. But many others prefer to work in an inter-disciplinary environment, where everything they do is concerned with the total system.

If you are interested in seeing and understanding the whole picture, rather than just a small segment of it, we think you'll be interested in System Development Corporation. Our work is concerned with the design and development of extremely large systems in which high-speed digital computers aid men in decision-making. The relative capabilities and roles of men, machines, and associated system components pose intriguing problems for creative minds.

At the present time we have key openings for engineers with proved analytical ability in the areas of communications, computers and associated equipment, simulation, information theory, weapons system analysis. Please send your inquiry to Mr. E. A. Shaw, SDC, 2424 Colorado Avenue, Santa Monica, California.

"A Mathematical Model of an Air Defense Operation and a Method of Evaluation," a paper by SDC's staff, is available upon request. Please address inquiries to Mr. E. A. Shaw at SDC.

SDC

SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California • Lodi, New Jersey

11-140

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Systems Engineers . . .
Solve the Puzzles of

UNDERSEA WARFARE

. . . WITH RCA!

RCA's Airborne Systems Division, a long-time leader in the development of airborne electronic systems and equipment, is now engaged in devising undersea warfare systems . . . to provide one of the most vital links in the chain of our defense. These systems necessitate the solving of challenging problems in the areas of general operations, sound propagation and signal recovery, and fire control.

As an RCA systems engineer, you will not only be responsible for creating some of today's most strategic defense weaponry . . . but will be able to advance rapidly, *as an individual*, on a highly liberal merit basis. Because of the far-reaching and important nature of your assignment, opportunities for professional growth are virtually unlimited. To keep you free for only *creative* activities, a vast array of well-staffed, well-equipped facilities—both research and manufacturing—are on hand to support you at all times.

A select number of openings now exist for systems engineers and operations analysis personnel with experience in sea or undersea warfare systems. If you qualify, you may secure further information by sending a résumé to:

Mr. C. B. Gordon, Dept. SA-30
Professional Placement Office
RCA, Bldg. 10-1
Camden 2, New Jersey

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA® **RADIO CORPORATION of AMERICA**
DEFENSE ELECTRONIC PRODUCTS

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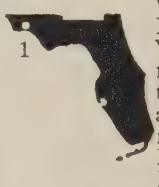
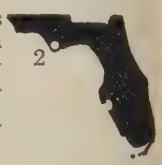
new openings in Florida with Vitro



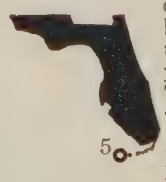
Vitro Laboratories' Florida operation, Vitro Weapons Services, is rapidly expanding its technical staff to operate the nation's newest missile test range, the EGLIN GULF TEST RANGE.

High level supervisory and staff opportunities exist at five Florida locations: 1. Fort Walton Beach; 2. Port St. Joe; 3. Tarpon Springs; 4. Naples and 5. Key West.



ELECTRONIC ENGINEERS — with degree(s) and several years experience in Automatic Tracking Radar, Electronic Instrumentation, Phase Comparison Space Positioning Systems, Data Recording and Conversion, Telemetry or Missile Range Instrumentation.

RADAR TECHNICIANS — with training and experience in one or more of the following radar systems: MSQ-1, MSQ-1A, FPS-16, Nike, M-33, MPS-9, SCR-584, CPS-6, FPS-3 and FPS-20.



ELECTRONIC TECHNICIANS — with a solid background in electronics and several years experience in Telemetry, Data Converters, Oscillograph Recorders or Range Electronic Instrumentation.

For your opportunity to relocate in Florida with an electronics industry leader, address a confidential resume to D. D. Cox, Personnel Director, Vitro Weapons Services, 119 East Main Street, Fort Walton Beach, Florida, Dept. SA.

Vitro LABORATORIES
DIVISION OF VITRO CORPORATION OF AMERICA
Other laboratories at West Orange, N. J., and Silver Spring, Md.

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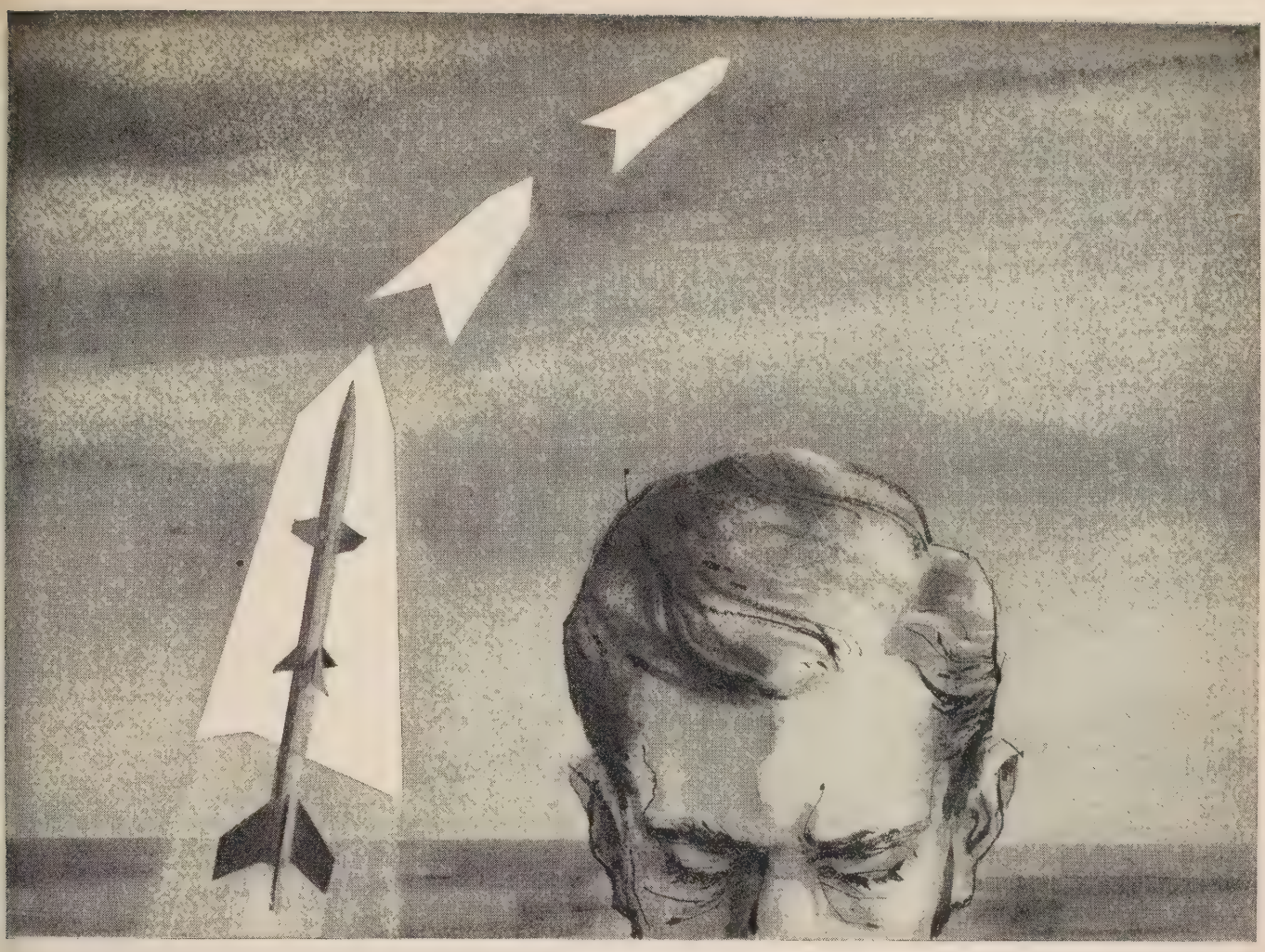

Frontiers are extended by the practical visionary

It is the practical visionary who has given us much of what we enjoy today. And it will be the visionary—the man with ability to seek concepts beyond the existing limitations of science —who will guide our developments of tomorrow.

The Applied Physics Laboratory (APL) of The Johns Hopkins University seeks men who will be engaged in advanced research problems—who will find solutions to problems yet to be posed. Their findings will provide guidelines for the space and missile hardware research of the future.

Your endeavors will be heightened by the professional atmosphere of APL. This atmosphere, created by men dedicated to the furtherance of science, has earned APL a reputation as a leader in programs vital to the national security.

Appointments at APL offer exceptional opportunities. For detailed information, address your inquiry to:

Professional Staff Appointments

The Johns Hopkins University Applied Physics Laboratory

8617 Georgia Avenue, Silver Spring, Maryland

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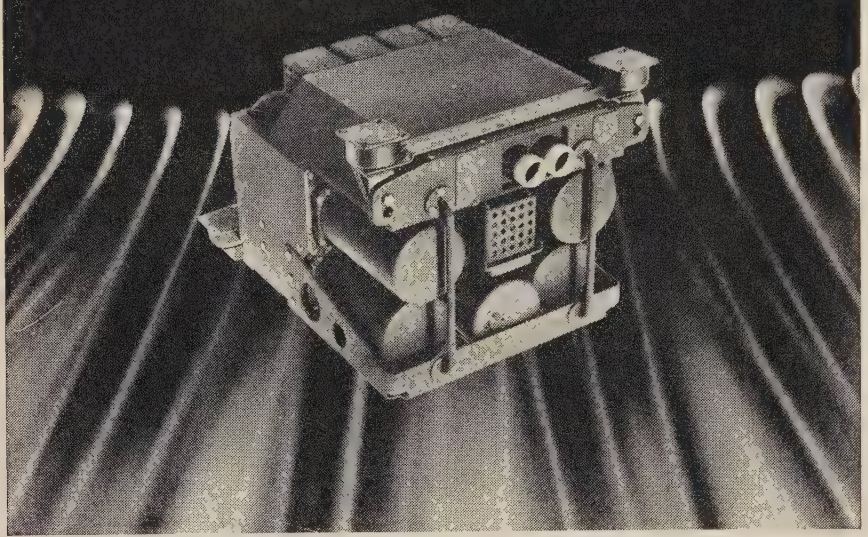
GROW WITH AIRESEARCH IN ELECTRONICS



• *AiResearch Central Air Data Computer for North American's A3J, Navy's first weapon system, provides information dealing with bombing, navigation, engine inlet control, radar, automatic flight control and cockpit instrumentation.*

Expansion in electronics and electromechanical activity is creating excellent openings at all levels for qualified engineers. Diversified programs include Central Air Data systems on the North American A3J, McDonnell F-4H and the Lockheed F-104 as well as other commercial and military aircraft and missile projects.

Openings in the following areas:

- **FLIGHT SYSTEMS RESEARCH** General problems in motivation and navigation in air and space; required background in astronomy, physics, engineering.
- **DATA SYSTEMS RESEARCH** Experience with physical measuring devices using electromagnetic, atomic, thermionic and mechanical approaches.
- **CONTROLS ANALYSIS** Work in preliminary design stage involves servomechanisms analysis and analog computer techniques.
- **FLIGHT DATA COMPONENTS** Analysis proposal, design and development work in the following specialties: circuit analysis, servo theory, transducers, transistors, airborne instrument and analog development of high and low temperature problems.
- **ELECTROMAGNETIC DEVELOPMENT** Work with magnetic amplifiers requires knowledge of electromagnetic theory, materials and design methods.
- **INSTRUMENT DESIGN** Electromechanical design of force-balance instruments, pressure measuring devices, precision gear trains and servo-driven positioning devices. Experience in electrical and electromagnetic transducers desirable.
- **AIRBORNE INSTRUMENTATION ANALYSIS AND DESIGN** Work involves solving problems in accuracy, response and environmental effects.

Send resume to:
Mr. Robert Richardson

THE GARRETT CORPORATION
AiResearch Manufacturing Division

9851 SO. SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

Check Employment Inquiry Form on Page 165

Now offering... creative careers in ordnance

Expanding operations in an exciting, growing company have created unusual career opportunities for ordnance engineers. Assignments on research and development projects will require the mature judgement of from two to ten years' experience in the field and present a combination of stimulating challenge and an ideal professional climate for contribution and personal development.

The company: the Crosley Division of Avco Corporation. There, confidence and personnel morale stem from aggressive management, a progressive approach to individual effort, and maximum support for all projects.

Definite creative career opportunities are available now. Experienced personnel can choose from:

- Ballistics
- Arming and Fuzing
- Non-nuclear Weapons Systems Analysis
- Target Damage Evaluation
- Warhead Design
- Shells System Design
- Microminiature Electronic Assemblies Design
- Projectile Design

For complete information, write or call: Mr. P. B. Olney, Manager of Scientific and Administrative Personnel, Dept. C-30, Crosley Division, Avco Corporation, 1329 Arlington Street, Cincinnati 25, Ohio. Phone: KIrby 1-6600.

Avco / Crosley

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product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

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This concept of man's attempt to harness bird power in an attempt to fly first appeared in "The Man in the Moon"—published in Paris in 1648. In 1659, the same mode of air travel was depicted in another book, "The Flying Wanderer" Here, Brussel-Smith, noted graphic artist, has interpreted the original drawing through the medium of wood engraving.

IMAGINATION IN SPACE

Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

This, then, is the working philosophy of Hercules in chemical propulsion: To design and manufacture highly concentrated packages of energy as propellants and rocket motors; each compatible, controllable, predictable; and each perfected for its specific mission.

HERCULES' BACKGROUND: A half-century of creative imagination in the evolution of propellants, from shotgun powder to the manufacture of every one of the millions of U. S. rockets fired during World War II, and now to space propulsion. Hercules facilities today encompass research, design, engineering, and staff organization for the production of the most advanced propellants. Illustrated brochure available on request.

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

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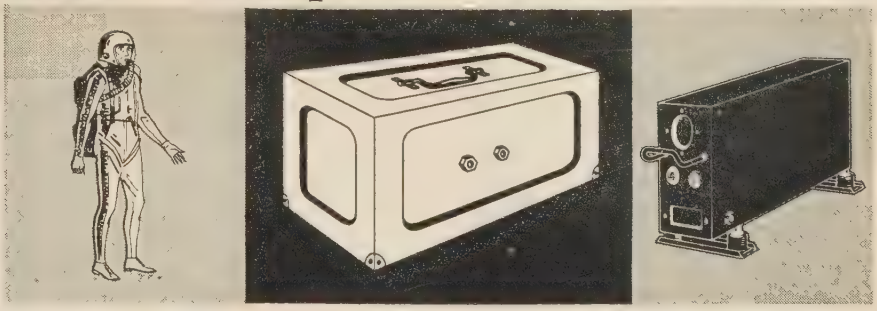
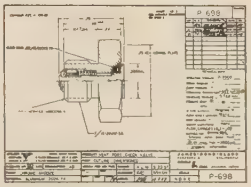
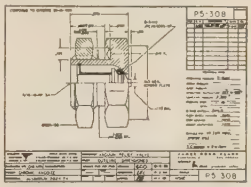
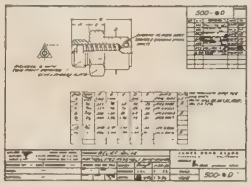
CIRCLE SEAL *specialized* RELIEF VALVES









For applications such as pilot suits, shipping containers, black boxes...

Circle Seal special relief valves provide:

- Protection against excessive pressure differentials
- Protection against moisture, dirt and contaminants
- Protection against vent port malfunction on missile solenoid valves
- Protection against electronic equipment damage
- Protection against pilot suit overpressurization

Circle Seal's many specialized valves provide "dead tight" sealing where it is required. They have been operationally proven in critical airborne applications—problem areas you may be exploring right now. Circle Seal's engineering know-how and experience can help you find the right solution.

Write for free engineering data!

CIRCLE ® SEAL
precision valves

JAMES, POND & CLARK, INC.
2181 East Foothill Boulevard
Pasadena, California

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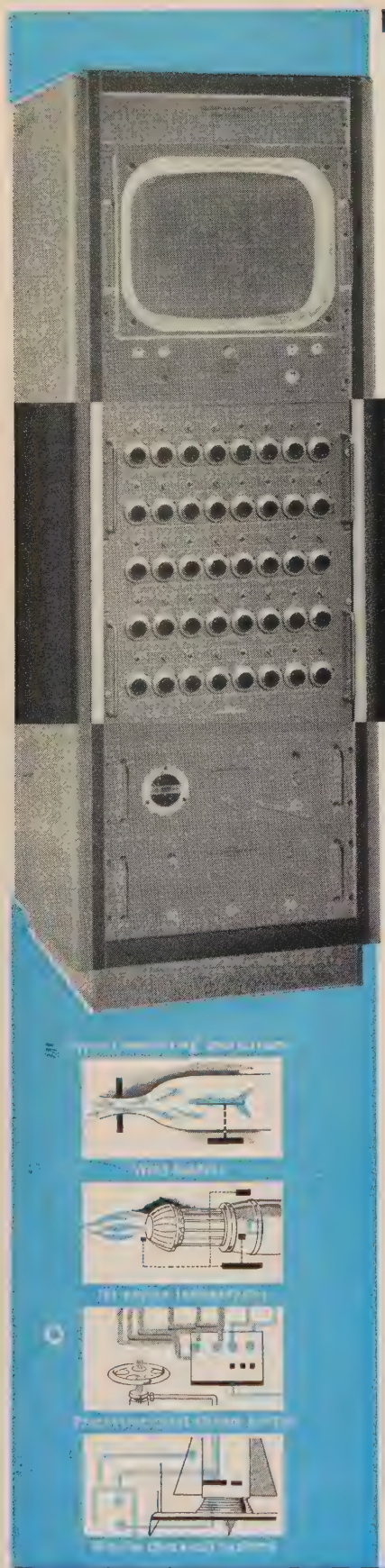
METAMORPHOSIS

See your R&D metamorphose into usable hardware. Our Inertial Guidance System contracts require that we add to our staff. If you have 3 to 5 years of experience, you probably qualify for a position of responsibility. Inquire today of Mr. C. T. Petrie, Manager, Research & Engineering Staff.

LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California



IN ONE ITT BAR-GRAPH OSCILLOSCOPE

40 CHANNEL READ-OUT

This single, ultra-sensitive display system does the work of 40 separate meters . . . provides quick-look convenience and accuracy for innumerable monitoring applications. Any 40 variables—related or unrelated—that can be converted into electrical signals can be studied, measured, and compared at once on the 17-inch scope of the Model 40BG.

Output of each of the channels is scanned ten times per second by means of a synchronous motor driven switch. Ultra-stable circuits provide maximum accuracy . . . line voltage variations cannot affect performance.

For complete information contact your ITT Instruments representative, or write us for Data File SA-1022-1.

ITT **Industrial Products Division**
International Telephone and Telegraph Corporation
15191 Bledsoe Street • San Fernando, Calif. • EMpire 7-6161
static power conversion • instruments • closed circuit television

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How CAMCO achieves foolproof maintenance with Ansco X-ray films

Central Aviation and Marine Company, Sayville, Long Island, is America's largest independent rebuilder of aircraft oil coolers. Inspecting a rebuilt cooler once took four hours by the old "rosette" method . . . and it was really an incomplete test that resulted in rejections by both the Air Force and airlines.

Now CAMCO has switched to X-ray examination. Total test time: 9 minutes. Rate of rejection: zero.

Says Ray Bennettson, "We've been using Ansco Industrial X-ray films for years. Other brands have been tried but have failed to provide the combination of speed, gradation and easy readability that we get from Ansco films."

CAMCO is just one example of the many operations depending on Ansco in critical non-destructive testing applications. Why not contact your local Ansco representative today for information. Ansco, Binghamton, N. Y., A Division of General Aniline & Film Corporation.

Ansco

X-ray

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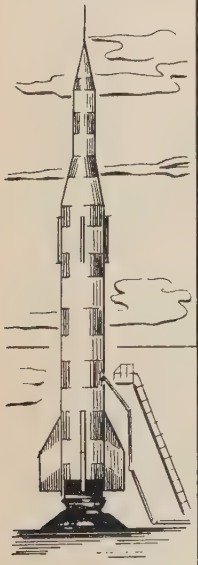
1st CHOICE...NOW *and for the* FUTURE



BARCO
FLEXIBLE
JOINTS
(Gimbal or Swivel)
FIRE-SAFE
PRESSURE-SAFE
SHOCK-SAFE
DETERIORATION-SAFE

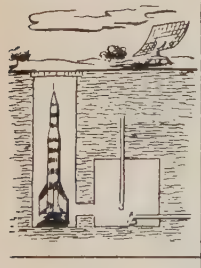
Barco is the leader in providing "Flexibility for Metal Piping" — the key to safety, permanence, and reliability wherever construction involves flow of fluids in missile launching, ground support equipment, or permanent base installations. Barco Flexible Joints are backed by years of successful engineering experience in this field and are available in sizes, styles, and types to meet current project requirements. Specify BARCO—NOW and for the FUTURE!

FOR MISSILE FUEL LOADING LINES

Barco "LOX" Joints meet requirements and have passed the official "qualification test" for handling cryogenic and other fluids used in fueling missiles, including liquid oxygen, nitric acid and other chemicals. Barco Joints for liquid oxygen are used for thermal contraction in piping and for making metal loading lines that are easily movable, flexible, and SAFE.

FOR HYDRAULIC ACTUATING LINES ON GROUND SUPPORT EQUIPMENT

Wherever hydraulic fluid is used to actuate movable parts of ground support equipment, any desired flexibility can be obtained with Barco Ball Bearing Swivel Joints installed singly or in "dog leg" assemblies in combination with metal tubing or pipe. Wide choice of designs approved for use.

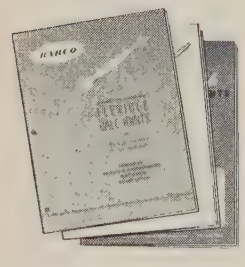


FOR SERVICE PIPING IN PERMANENT LAUNCHING SITE INSTALLATIONS

Widely used to protect vital pipe lines against "shock", up to 50 G's or more, Barco Ball Joints also have broad application in building permanent underground missile facilities where space is limited and service piping must be allowed to expand thermally and also be protected against the shock effects of possible blasts. Choice of sizes ½" to 16".

ASK FOR RECOMMENDATIONS — We invite your inquiry and will be glad to provide engineering recommendations. Industry-wide sales and service. Literature on request:

Catalog 233A—"Flexible Ball Joints for Handling Liquid Oxygen and Missile Fuels."
Catalog 269B—"Plane and Self-Aligning Swivel Joints for Hydraulic Service."
Catalog 215B—"Barco Ball Joints for Flexibility in Piping."
Bulletin 31A—"Ball Joints for Expansion or Contraction in Fixed Piping."



BARCO
MANUFACTURING CO.
575D Hough Street
Barrington, Illinois

FLEXIBILITY FOR METAL PIPING
Serving Industry Since 1908

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CLASSIFIED

MISSILE FLUID POWER COMPONENT DEVELOPMENT

Major midwestern manufacturer with R & D center in Cleveland area has key opening for creative engineer with supervisory ability and practical experience in missile fluid power component design. Unusual opportunity for rapid advancement with company just entering this field, for qualified engineer. Excellent model shop and lab facilities available.
Send resume to Box #310; Space/Aeronautics; 205 E. 42 St., New York 17.

Ultra high strength wire ribbon being formed into a rocket case on specially designed wrapping machine.

UNIQUE BENDIX WIRE *RibbonWrap* REDUCES WEIGHT, INCREASES RELIABILITY OF ROCKET CASES

s has licked the problems of weight iability in flight weight pressure ves- ecret of the Bendix-developed rocket many tiny ultra high strength steel formed by adhesive bonding into a efficient ribbon. Weight and distribu- the binding adhesive is precisely con- l. Result—rocket cases with test th as high as 531,000 psi, *equivalent oop stress of 350,000 psi UTS in a homogenous case.* A specially designed Bendix machine generates the rocket case. The best wrap pattern for each case is mathematically determined and precisely controlled. Finished product is a rocket case tailor-made for configuration, strength and reliability.

For more complete information, write Rocket Equipment, Bendix Products Division, South Bend, Indiana.

The Bendix wire RibbonWrap gives you these important advantages:

Design Flexibility
Controlled Minimum Weight
Close Tolerances
High Temperature Strength
Shortest Prototype or Production Lead Time
Automated for Low Cost
Inherent Reliability

Bendix PRODUCTS DIVISION South Bend, IND.

Bendix AVIATION CORPORATION

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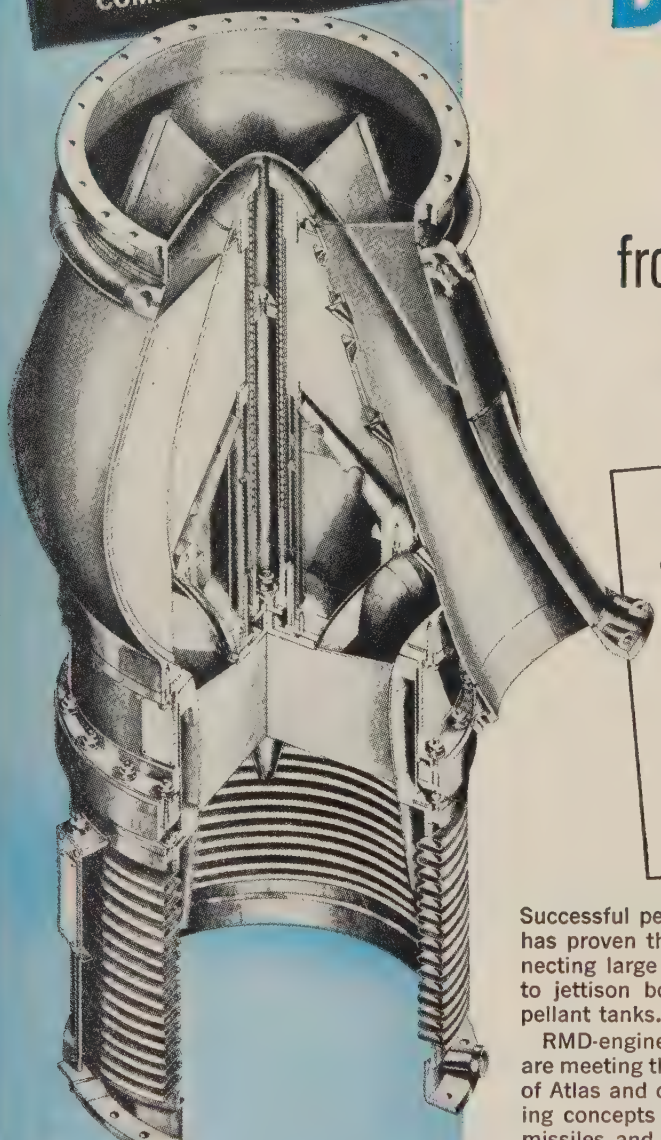
Suited to most advanced concepts in space vehicle and large missile configurations

Products of COMPONENTS DEPT., RMD

DISCONNECT VALVES

from Reaction Motors Division of Thiokol



Western World's Largest Flying Valve, at left:

- 11″ line size
- Cryogenic Application (liquid oxygen)
- Combination disconnect—check valve—flexible duct
- Lightweight. 50 lbs. All sheet metal construction
- High flow rate—6500 GPM at 175 psi
- Minimum pressure drop—2 psi
- Missile qualified (Atlas)
- Provides for angular and axial misalignment and lateral displacement of mating ducts

Successful performance of the Atlas has proven the feasibility of disconnecting large lines in flight in order to jettison booster engines or propellant tanks.

RMD-engineered disconnect valves are meeting the operational demands of Atlas and can be adapted to staging concepts now current for global missiles and space vehicles.

Disconnects from RMD are presently available in a variety of line sizes—from 4″ to 11″. They're lightweight, compact and are designed to handle cryogenic, conventional, exotic and corrosive fluids and storables.

Whether your assignment involves the planning of tomorrow's missiles or the refining of those now operational . . . look to RMD for the right propulsion system components.

For complete information, contact

Reaction Motors Division

Thiokol® CHEMICAL CORPORATION

Ford Road, Denville, New Jersey

9″ Disconnect with Universal Fluid Coupling

8″ Disconnect Valve

5″ Disconnect (tank mounted)

4″ Disconnect Valve

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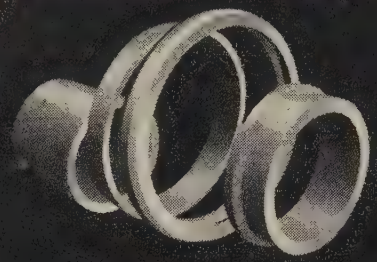
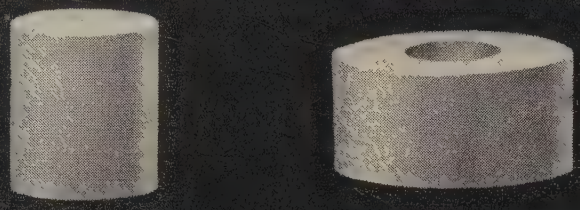
why

Edgewater rolled steel rings

are best . . .



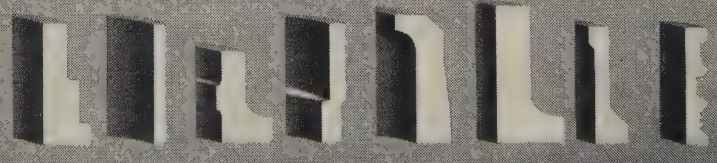


A solid steel block is heated to forging temperature, and thoroughly soaked.

The block is upset on a forging press, and the center is punched out.

On the rolling mill, the heated punched block revolves between main and pressure rolls, where its diameter grows and section shape is formed. Edging rolls control width.

Below—representative sections of rings rolled by Edgewater.



From a solid block of steel, a solid ring has been formed, to required size and shape. The accuracy possible with this process greatly minimizes the need for further finishing. Diameters are from 5 to 145 inches, weights up to 14,000 pounds. Materials include carbon and alloy steels, stainless, tool steels, titanium. Facilities available for machining and heat treatment.

Write for descriptive bulletin.

Edgewater Steel Company

Dept. SA • P.O. Box 478 • Pittsburgh 30, Pa.

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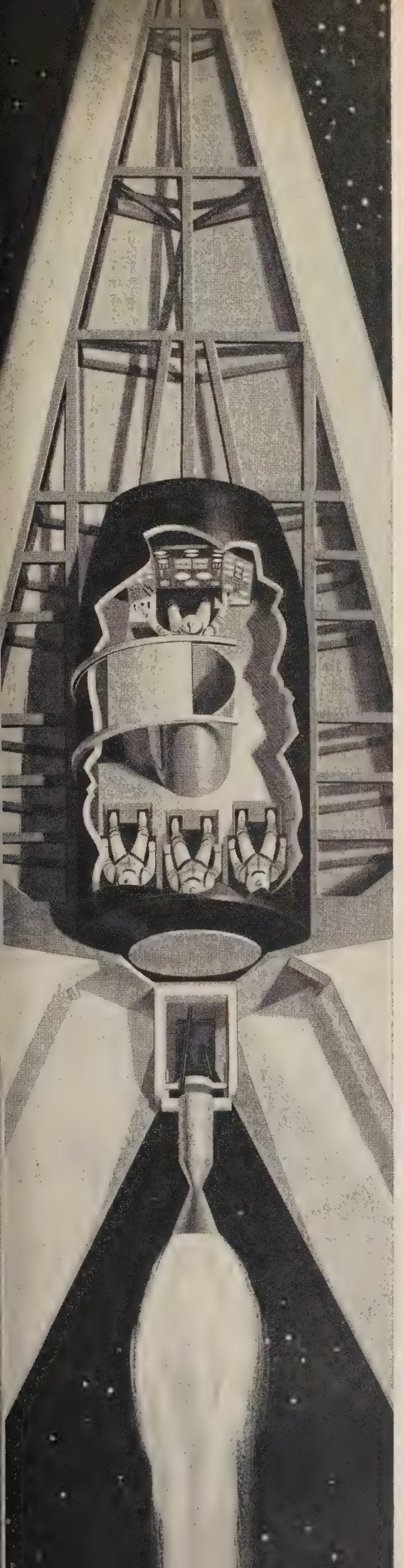
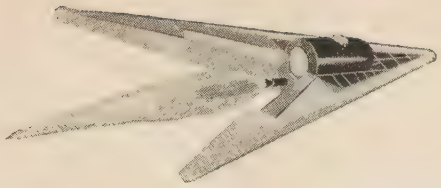


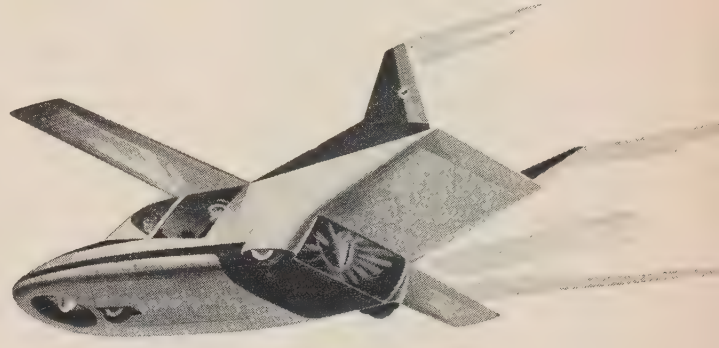


FUTURE PROJECTS LOOM LARGE AT LOCKHEED

There has never been a time in the long and distinguished career of Lockheed when it has not looked to the future; when it has not considered how best to use its store of engineering and scientific knowledge and the capabilities of its personnel. This is more true today. Lockheed's advanced thinking in the transportation and communications complex is twofold:

1) To advance the state of the art in space/age applications.
2) To improve standards of living.

Pictured here are examples of Lockheed's project-plans in advanced areas: The strike reconnaissance concept as a counter weapon to mobile missile launching; providing our foot soldiers with safety and air mobility; revolutionizing automobile transportation with an automatic destination system; transmitting telemetered motor instructions from a human operator to a machine; advanced infrared navigational methods for space applications; family-sized air vehicles utilizing lift augmentation; studying all physical aspects of living in a space environment and correspondent instrumentation and telemetry; flight vehicles for safe, fast, economical, atmospheric and space travel.



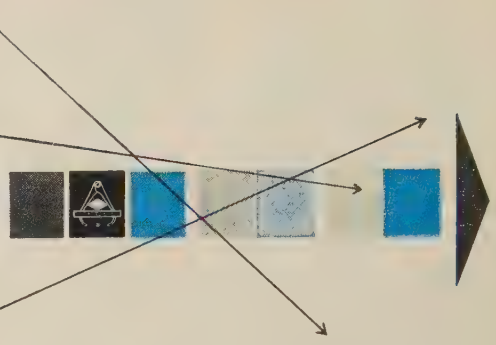
High-caliber scientists and engineers are invited to explore Lockheed's long-range plans—future projects that offer great rewards for men of great promise. Openings are available in: Aero-thermodynamics; electronics—research, systems, packaging; servosystems and flight controls; experimental physics; astro-physics; bio-physics.

Please address your inquiry to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1903, 2401 North Hollywood Way, Burbank, California.

LOCKHEED | CALIFORNIA DIVISION

Check Employment Inquiry Form on Page 165

Garlock's main objective

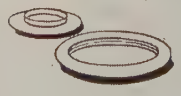


in missiles work . . .

Filament wound rocket motor cases made by exclusive Garlock method result in structure much lighter and stronger than steel.

Insulation for solid fuel rocket motors made by Garlock is rubber-like compound which encounters gas velocities of Mach 3-5, temperatures to 5500° F., prolonged ambient temperatures of 300° F.

Missile parts from inert materials including newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.



Garlock metal fittings for rocket motor cases such as blast tube and thrust terminator support rings are machined to extremely close tolerances. Made from special materials affording minimum weight, maximum strength and rigidity.

is delivery of high quality rocket motor components in the shortest time. To reach this common goal, research and development, product design, tool design, pilot manufacturing, and production staffs work together as a fully integrated team. They solve problems of design and production jointly, thus eliminating weeks of possible re-designing and re-tooling.

Garlock is flexible: they'll swing into prototype production on short notice and follow this with full scale production as needed. *Garlock is diversified:* they'll design and manufacture rocket motor components from a variety of basic materials—rubber, metals, phenolics, fluorocarbon plastics.

Garlock engineers will work to your design or help you in developing designs. Call or write Military Products Department, The Garlock Packing Company, Palmyra, N. Y.

GARLOCK

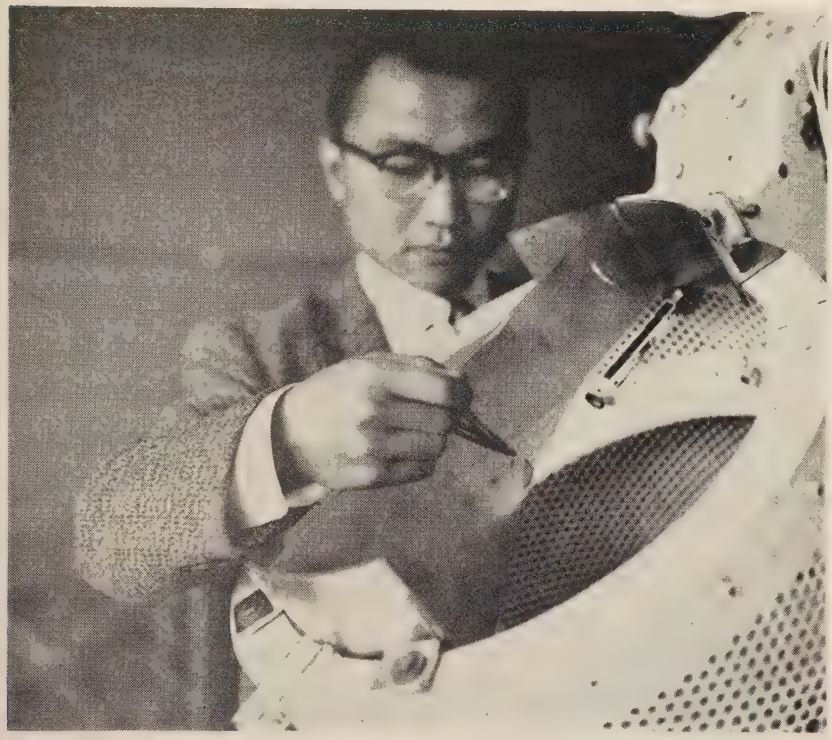
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Garlock components are presently used in the development and production of:

• Vanguard • Super Vanguard • Polaris • Minuteman • Nike Hercules • Terrier • Super Tartar

Write in No. 170 on Reader Service Card at start of Product Preview Section

equipment briefs



TELESCOPE MIRROR

LAST summer, a remotely controlled telescope built at Princeton University and suspended from balloons at altitude of up to 82,000 ft took some of the most detailed photos of the sun that have been made so far. An eight-foot tube, the telescope has a parabolic quartz mirror at one end and a secondary plane mirror and a prism at the other. Light gathered by the parabolic mirror is reflected back along a path above the telescope tube into a 35-mm motion picture camera.

In earlier designs, the secondary mirror was made of quartz with an aluminized surface. As a result, it had continuously rotated to prevent overheating, which would have distorted the reflected image. In the new telescope, the secondary mirror is made of Haynes alloy No. 25, developed by Haynes Stellite, of New York City, and is fixed. As vibration effects are now eliminated, sharper pictures can be taken.

The optically polished secondary mirror is welded onto a copper sheet. When the hot image of the sun falls on it, the heat dissipates through the mirror, the copper sheet, and the telescope tube. This combination heat sink prevents the air surrounding the mirror from heating and causing image distortion.

STAINLESS FLUID FILTER

A MAJOR problem in the filtration of corrosive fluids is the cost of filter replacement. Purolator Products, Inc., Rahway, N. J., now has produced a metal-edge-type filter that greatly reduces the replacement problem. The filter is constructed by winding many yards of stainless 304 alloy ribbon to form a cylinder. Formed risers separate one ribbon layer from another by a precise distance. Spacing between the stainless ribbons must be controlled to 0.02 ± 0.0005 in. in 500-micron filters. In assembly, the layers are spot-welded, so that the filter is a single welded unit.

Stainless 304 alloy was chosen for the filter for three reasons:

- corrosion resistance under all conditions.
- full filtration regardless of temperature variations,
- satisfactory forming and welding. Write in No. 56 on Reader Service Card for more information.

REVISED DRAWING FORMAT

THE engineering drawing is undergoing a change at Boeing Aircraft Co., Seattle, Wash. A series of studies has shown that changing the structure of the engineering drawing would save time, material, and paperwork—and would also make information more readily available. It was found that drawing users often require only the field of the drawing. In other instances, only the bill-of-materials is required.

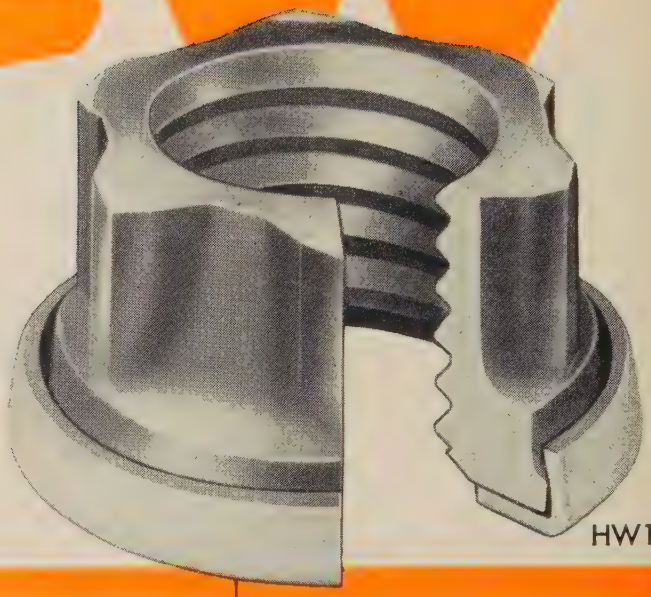
In Boeing's new format, the field of the drawing remains unchanged. The written information, however, is prepared in loose-leaf form—under the same identification number as the field of the drawing. With this arrangement, users draw only the material required for a specific job.

The revised system also makes engineering changes easier. Revisions of informational data merely involve new loose-leaf pages. Other changes will continue to be attached to the drawing.

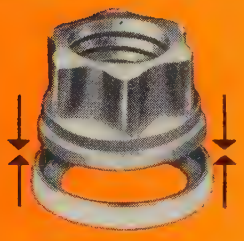
NEW

KAYLOCK® "CAPTIVE WASHER" NUT

ENDS WASHER WANDERLUST

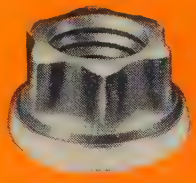


HW14



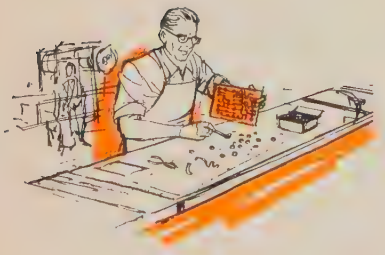
Enlarged view of Kaylock H14-3 and washer prior to assemblage.

Assembled HW14-3. Integral, free-spinning washer can't drop off. Only one part to buy instead of two.



Complete assemblage.

Service Temperature: 500°F.
Tensile Strength: 160,000 PSI.
Material: Carbon Steel. Also in A286 for 900°F. applications.



Costly time is wasted on washers with wanderlust. Small, slippery, they roll away, drop off, slide into the hardest-to-get-at places. Now, Kaynar has solved the problem with the new Kaylock HW14 "Captive Washer" Nut, an H14 lightweight, all-metal, self-locking nut with integral, free-spinning, metal washer. Stabilizes frictional characteristics between nut base and aircraft structure. Result: controlled joint tightness.

Saves Assembly Time. Kaylock HW14's cut extra motion required to put washer on bolt. Washer can't drop off during application or removal. Cuts time lost looking for wayward washers . . . *to zero.*

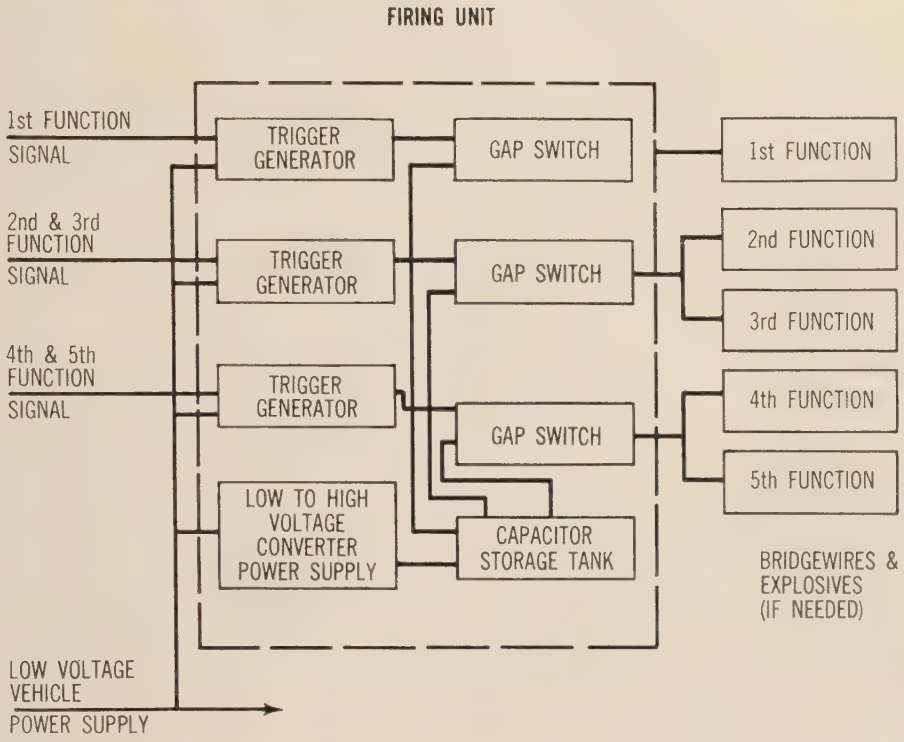
Safer too. There is no chance of equipment jamming or becoming destroyed because of nuts and washers vibrating loose. Kaylock HW14 nuts employ the same, sure elliptical locking principle to prevent vibration hazards. The Kaylock HW14 is a new product development of Kaynar Mfg. Co. Inc., world's oldest and largest manufacturer of lightweight, all-metal, self-locking nuts. For further information, contact your Kaylock representative or write or call Kaynar directly.

Trade Mark

Kaylock ALL METAL SELF-LOCKING NUTS®

Kaynar Mfg. Co. Inc., Kaylock Division, Box 2001, Terminal Annex, Los Angeles 54, Calif.
Branch offices, warehouses & representatives in Wichita, Kansas; New York, N.Y.; Atlanta, Ga.; Renton, Washington. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

Write in No. 171 on Reader Service Card at start of Product Preview Section



EXPLODING BRIDGEWIRE is fail-safe, versatile

MARCH 1960

Librascope, Inc., Glendale, Calif., has developed an exploding bridgewire (EBW) system announced as "a new concept in missile ordnance system safety and reliability". It can be used for stage separation, ignition, thrust cutoff, destruct, and other ordnance functions. A wide range of configurations makes the system a direct replacement for conventional detonation systems and provides unequaled safety and reliability along with weight and space savings in multi-stage vehicles.

To explode the bridgewire, a high energy pulse of extremely short duration is used, which is generated by a special firing unit in the EBW system. The pulse is such that it makes the EBW immune to false firing by low dc voltage potentials in the missile systems and to high energy radio frequency fields.

Write in No. 405 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor

product preview

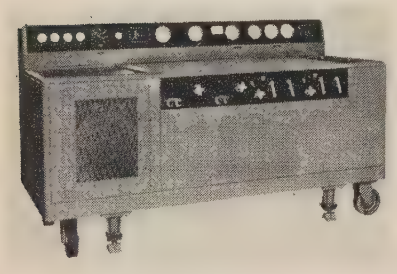
CONNECTOR
has relief handle

This connector is for use with film insulated flat conductor wiring. The plug-in units incorporate an insulated strain relief handle which is mountable to either male or female connector, says **Methode Mfg. Corp., Dept. S/A, 7447 W. Wilson Ave., Chicago 31, Ill.**

Both rack-and-panel and cable-to-cable connections are accommodated by the in-line construction.

Write in No. 409 on Reader Service Card

TEST STAND
for high pressure



This portable 5000 psi pneumatic test stand, model 9887, for simulating high pressure pneumatic systems to test precision components, such as missile attitude controls is self-contained. It delivers up to 15 cfm of dry air at 100F under continuously variable pressures from 0 to 5000 psi, says **George L. Nankervis Co., Dept. S/A, 15400 Fullerton Ave., Detroit 27, Mich.** Automatically controlled desiccant driers remove moisture from the air system to a dew point of —40 deg F for 8 hours of operation before the driers need reactivation.

A 1½ cu ft container stores dry air under pressure.

Write in No. 410 on Reader Service Card

POWER SUPPLY
is transistor-regulated

This low voltage, transistor regulated, power supply is designated the PTR series and ranges in output from 10 to 50 v dc with choice of fixed or adjustable output. Input requirements are 105-125 v, 50-63 cps, says **Power Sources, Inc., Dept. S/A, South Ave., Burlington, Mass.** Regulation: less than 0.5 per cent (full load to half load) less than 1.0 per cent (half load to no load). Stabilization: Less than ±0.5 per cent change in output voltage for ±10 per cent change in input voltage with constant load.

All models are said to meet the general requirements of military specifications for ground based equipment.

Write in No. 411 on Reader Service Card

SPEED MONITOR
for engines

This speed monitor, a compact engine control device weighing 1 lb, having an accuracy within ½ per cent of setting, is a flyball type governor containing flyweights resisted by calibrated spring force. Centrifugal force becomes a thrust on an actuator that operates two snap action electrical switches, says **General Motors' AC Spark Plug Div., Dept. S/A, Milwaukee, Wis.** The unit is capable of operating in a speed range of 500 to 5000 rpm at temperatures of —65 deg to 250 deg F with a life expectancy of over 2000 hours.

It is permanently lubricated and ignition proof, not affected by altitude or sand, dust or fungus.

Write in No. 412 on Reader Service Card

GENERATOR
for 37 waveforms

This model LF 51 generates more than 37 different waveforms for testing servomechanisms, vibration studies, medical research and geological problems as well as programing automatic systems and analogue computation. Sine waves with frequencies from 500 cps to 0.005 cps (1 cycle every 35 min) are generated with total harmonic distortion less than 1 per cent, says **Marconi Instruments, Dept. S/A, 111 Cedar Lane, Englewood, N. J.** Maximum voltages are 150v peak to peak. Ramps, triangular waves, sawtooth and trapezoidal functions are available singly or repetitively.

Non-linear functions are formed from triangular waves with a special shaping resistor controlled by a chain of biased diodes. The instrument comprises 16 modules plus a fully stabilized power supply housed in a rack mounting cabinet. It will withstand 40g's in any direction.

Write in No. 413 on Reader Service Card

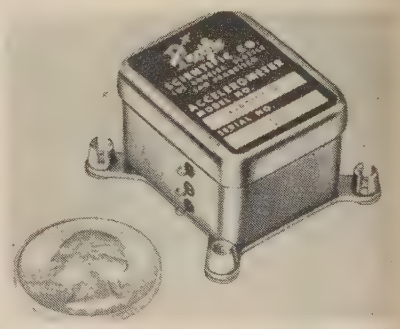
CARD RECEPTACLES
use direct plug-in

These printed circuit boards are made to environmental requirements of MIL-C-21097. They are available with optional threaded mounting inserts and with vibration resistant card-locking clips, with which a screw driver or similar instrument is employed to release the latch, says **Methode Mfg. Corp., Dept. S/A, 7447 W. Wilson Ave., Chicago 31, Ill.**

Direct plug-in construction can be utilized with these 3/32 in and ⅛ in card receptacles.

Write in No. 414 on Reader Service Card

ACCELEROMETER
is subminiature



This potentiometer-type accelerometer measures 1.1x1.5x1.8 in deep. It delivers 2 per cent accuracy over a —10 to +30 deg F range, and is designed for telemetering and control, says **Pacific Scientific Co., Dept. S/A, 6280 Chalet Dr., Los Angeles, Calif.** Silicon fluid damping is utilized for shock and vibration immunity.

Temperature range is from —55 deg C to +82 deg C.

Write in No. 415 on Reader Service Card

PRESSURE TRANSDUCER
weighs 2½ ounces

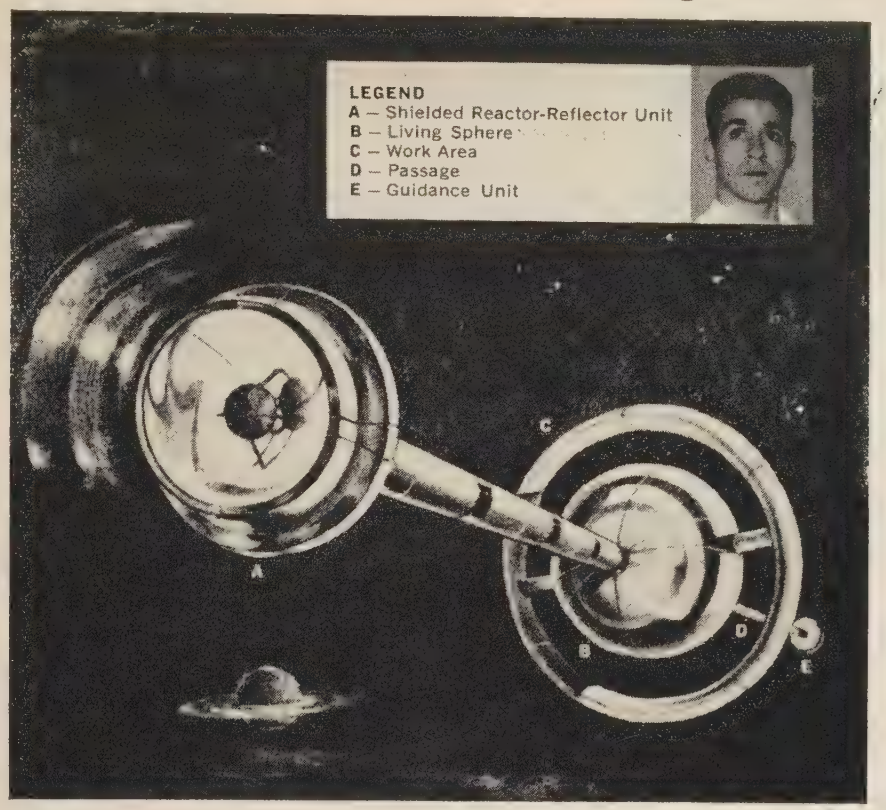
This miniature, series 401, pressure transducer measures 1x1 in square and will accept vibration ±35 G at frequencies to 5000 cycles per second. It weighs 2½ ozs, has a diaphragm capsule, the motion of which actuates the wiper of a precision potentiometer, says **Colvin Laboratories, Inc., Dept. S/A, E. Orange, N. J.** The instruments are available for absolute, differential and gauge pressures from ±3 to ±200 psi.

Standard nominal potentiometer resistances are 2000, 2500, 5000, 7500, and 10,000 ohms. Electrical connection is by soldering terminals or pigmy receptacle.

Write in No. 416 on Reader Service Card

more on page 190

No. 17 • Mars Outstanding Design Series



LIGHT TRAVEL – You may need to postpone your trip a half century or more but you will make up for lost time. So says Philip Schlesinger, of Buffalo, N. Y., who designed this light-powered space ship which will take you to distant space at almost the speed of light.

Based on Einstein's theory that matter can be converted into light, this Photon Powered ship derives its basic power from a small atomic reactor. The reactor is housed in a unit which also contains reflectors. Comparable to fluorescent screens, these convert the reactor heat, under great pressure, into light and thrust. The thrust is low, but extremely constant.

Launched disassembled inside a cargo rocket, the ship is assembled in space. It cannot land (a landing vehicle is provided for that purpose), but remains in orbit.

This is one more example of the creative contributions today's designers are making. To help them translate their pace-setting ideas from concept to reality, they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.

Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar–for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

®T.M. FOR duPONT'S POLYESTER FILM

for the man who's going places...

the pencil that's as good as it looks

MARS

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

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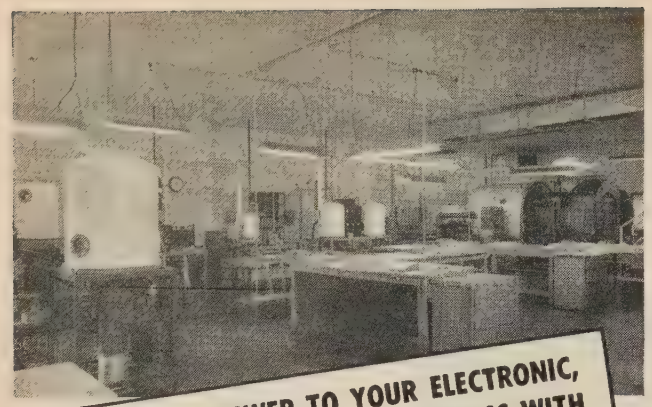

FIND THE ANSWER TO YOUR ELECTRONIC, OPTICAL AND INFRA-RED PROBLEMS WITH

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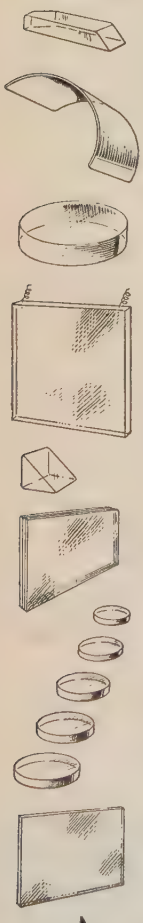
PRECISION EVAPORATED FILMS



Have you explored the possibilities of controlling REFLECTION, TRANSMISSION, ABSORPTION and EMISSIVITY with KINNEY Precision Evaporated Films? Here are advanced techniques, backed by years of research and successful production of optical and electrical films applied to a broad range of surfaces and substances. These development and production facilities are available to you: Front and Back Surface Mirrors—any metals... Low Reflection Films—any wave length... Semi-Transparent Films . . . Dichroics . . . Beam Splitters . . . R.F. Shielding . . . Anti-Electrostatic Films.

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VACUUM EQUIPMENT DIVISION
THE NEW YORK AIR BRAKE COMPANY
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Please send copy of Bulletin No. 4900.1 describing KINNEY Precision Evaporated Films.

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Company_____

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City_____ Zone____ State_____

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PRESSURE PICKUP for missiles

Model 4-380A is a potentiometer pressure pickup that will operate in such missile conditions as high-g acceleration and vibration for sustained periods. It will withstand 100 G shock and static acceleration on three orthogonal axes without damage or unusual response, says **Consolidated Electrodynamics Corp., Dept. S/A, Sierra Madre Villa, Pasadena, Calif.**

In addition the instrument is built to operate in vibration environments up to 25 G for many hours and throughout the frequency band to 3 Kc. Operational temperature range is from –65 deg F to 200 deg F. Maximum temperature is 300 deg F.

Write in No. 419 on Reader Service Card

MULTICODER in compact design

The design of the Model 1208D-2 PDM Multicoder has resulted in a 4 x 4 x 4-in device that samples 88 instrument channels and simultaneously produces PDM and PAM output waveforms, says **General Devices, Inc., Dept. S/A, P. O. Box 253, Princeton, N. J.** The all-electronic unit, which is built to withstand space-vehicle environments, will drive a standard magnetic record head from the PDM output and a standard SCO from the PAM output.

All necessary auxiliary power supplies and blanking and keying circuitry are contained in the solid state device, and it operates directly from a nominal 28-V supply drawing three W.

Write in No. 420 on Reader Service Card

SERVO ANALYZER generates square waves

This servo analyzer has wide frequency coverage and the integrator is said to contribute accuracy and stability. Frequencies are indicated on a 4 in dial that permits readout over entire range. A special circuit design is used for generating square waves, assuring transient-free wave forms even at extremely low frequencies, according to **Aetna Electronics Corp., Dept. S/A, Readington Rd., N. Branch, N. J.** A 100 to 1 attenuator is provided.

Both front and rear of the cabinet are equipped with output terminals. The analyzer will accept carrier frequencies from 50 to 5000 cycles and has an internal carrier source of 5000 cycles.

Write in No. 421 on Reader Service Card

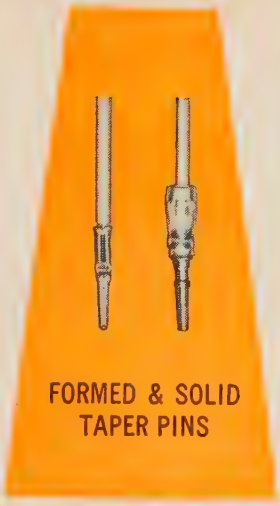
TRANSDUCER for tilt angle

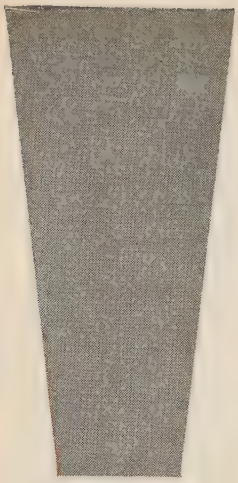
This Electronic Tilt Angle Transducer is an optical-electronic device capable of automatically detecting and recording angular change to within ¼ second of an arc, a degree of accuracy unattainable by other methods, states **Keuffel & Esser Co., Dept. S/A, Hoboken, N.J.** The instrument can be used to measure positional disturbances of structures such as guided missile launching platforms, radar tracking systems.

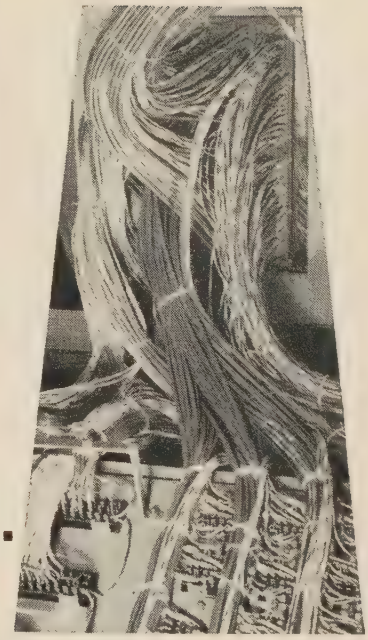
Used on a launching platform, the disturbance signal from the instrument can be fed directly into a servomechanism to make the platform self-leveling. In long-range radar tracking, it is capable of monitoring the motion of the axles and recording, wth a time index, the information needed to correct the basic data.

Write in No. 422 on Reader Service Card

more on page 192







FOR A TIGHT FIT IN A TIGHT SPOT...

miniaturization has put your circuits in a tight spot, you can build reliability right into them with the AMP aper Technique . . . formed taper pins or new solid, pre-insulated taper pins . . . two-piece or molded one-piece tackable blocks . . . plus a wide assortment of taper receptacles.

he AMP Taper Technique offers the most complete line of taper products available plus many extra features. three-and-a-half degree taper assures the firmest fit of pin in block. A-MP Pull-Test Insertion Tools assure the roper seating of pins. Hand and Automachine crimping tools assure uniformity of pin attachment to your ircuit leads.

nd—with the addition to the AMP Taper Technique of the new Solid Pre-Insulated Diamond Grip Taper Pin nd the new one-piece warp-free block, you can have the greatest flexibility of product choice for your circuit esign and manufacturing operations.

ou can concentrate more circuits in a smaller space—and be sure of reliability when you use the AMP Taper echnique. Send for our new catalog today.

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Edcliff
TRANSDUCERS
SERIES 7

High accuracy Accelerometers

FOR INFINITE AC OR DC PICKOFF

Edcliff Instruments' Model 7-34 differential transformer accelerometers are extremely rugged instruments, designed for missile and airborne applications. Built for reliable operation under adverse environmental conditions, the new accelerometers are frictionless and almost insensitive to shock and vibration.

OUTSTANDING APPLICATION FEATURES

Wide Range of Frequency Responses.
AC or DC Output.
Ranges, ±0.5 up to ±50 G, symmetrical or unbalanced.
Temperature Compensated Damping without heaters.
High Power Output.
5 to 200 VAC Input, 400 to 10,000 cps.

Edcliff Instruments has a production model accelerometer for every application. Let Edcliff supply the "feel" for your guidance system. Write today for your free application data catalog.

Edcliff
INSTRUMENTS
1711 South Mountain Avenue
Monrovia, California

Write in No. 175 on Reader Service Card

STRAIN GAGE CEMENT for service to 400 deg F

These epoxy cements were formulated for use with bonded filament strain gages to bond the small, postage-stamp size gages firmly to any test material. They are designated as EPY-150 and 400, and have maximum service temperatures of 150 deg F and 400 deg F, respectively, says **Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Dept S/A, 42 Fourth Ave., Waltham 54, Mass.** Both types are in small plastic packs, each divided into two compartments containing the liquid adhesive and activator. The cement is mixed for use.

EPY-150 is available in boxes of ten 6, 8-gm plastic packs. The 400 is supplied in boxes containing three 20-gm packs or one 100-gm pack. Shelf life is six months or more.

Write in No. 423 on Reader Service Card

TV CAMERA has good resolution

More than 600-line resolution is obtained in this closed-circuit TV camera, which has an eight-mc bandwidth, says **Packard Bell Electronics Corp., Dept. S/A, 12333 W. Olympic Blvd., Los Angeles 64, Calif.** The unit is designed with a single operating control, fully regulated power supply, keyed automatic black level control, and automatic light compensator.

Video output is 1.4 V peak to peak composite signal with 30 per cent sync, frame frequency is 30 per sec, and vertical and horizontal sweep frequencies are 60 and 15,750 cps, respectively. Available remote accessories include auto-zoom lens, control turrets, and weather-proof housing with windshield wiper.

Write in No. 424 on Reader Service Card

PRESSURE SWITCH weighs 4 ounces

This pressure switch weighs 4 ounces and measures 3 in in length by 1½ in at widest diameter. Ambient temperature range is —65 deg F to 300 deg F, but special versions can be provided for temperatures up to 600 deg F. The No. 1580 is factory set to actuate at a desired pressure level with the range of 0.5 psi up to 4,000 psi, says **Haydon Switch, Inc., Dept. S/A, Waterbury, Conn.** All moving parts are in an aluminum housing environmentally sealed by O-rings at each end.

Unit is resistant to corrosive operating media, such as water-alcohol solutions, nitric acid and hydrogen peroxide.

Write in No. 425 on Reader Service Card

ISOLATORS for shock and vibration

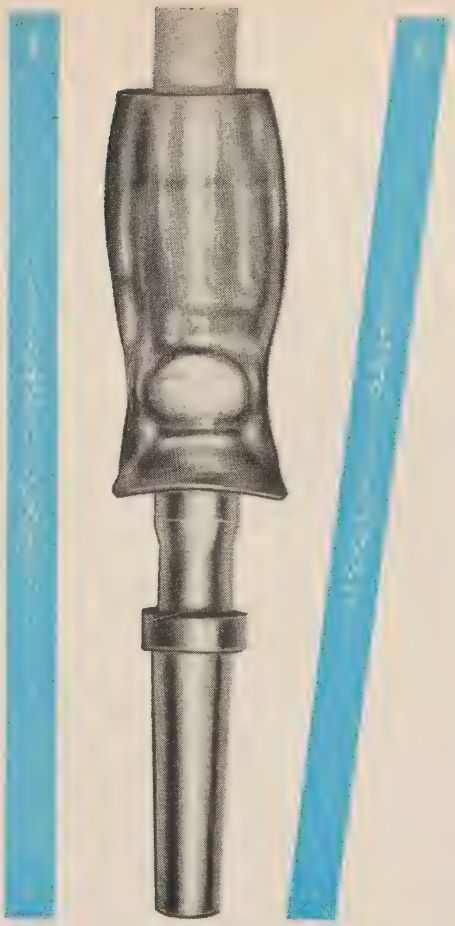
These isomode shock and vibration isolators for use at temperatures up to 500 deg F. provide protection encountered in aircraft and missiles. Vibration sensitive airborne equipment such as radar antennae and electronic gear require effective isolation from high-frequency vibration, says **MB Electronics, Dept. S/A, 20 Fitch St., New Haven 11, Conn.** They consist of two load carrying springs mounted in opposed positions.

Diameters of springs, wire diameter, assembled length, number of turns of wire in springs, and helix angle of spring are so controlled as to provide spring rates in directions parallel to and perpendicular to the axis of the isolator.

Write in No. 426 on Reader Service Card

more on page 196

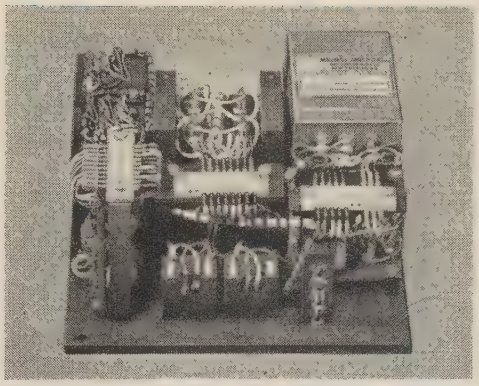
AMP taper technique points the way to greater reliability



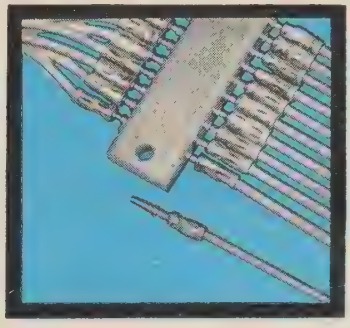
Magnetic Amplifiers, Inc. of New York carefully manufactures its Static Inverters with a step-by-step quality control and testing program to build in the reliability required for aircraft and missile applications.

It found that AMP Taper Technique simplified this procedure. A high speed AMP Automachine pre-terminates circuit leads with crimp-type, pre-insulated solid Taper Pins. Components are then easily tested in the modular stage before final assembly. Crimping eliminates difficult soldering operations and the danger of burning wound components while Taper Technique permits checking and trouble shooting without destroying the main cable. After final assembly, when the Pins are inserted into the Blocks, this Technique provides rugged vibration resistance and operational reliability.

AMP solderless Taper Pins are made in formed and solid types, with or without pre-insulation and mate with a wide range of one or two piece stackable Taper Blocks. You'll find that AMP Taper Technique is ideal for *your* quality control or circuit density problems too.



Magnetic Amplifiers' 250VA Static Inverter Model SIS-425041



AMP Pre-Insulated Taper Pins and stackable Taper Blocks

Write for our new Taper Technique brochure.

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Thermal Protection Systems: No single material possesses the range of complex properties necessary to withstand the high temperatures of missile and space requirements. To solve this problem, composite materials and structures that combine the desirable characteristics of several materials, are being developed. Some of these approaches include insulating layers and heat sinks; transpiration, film or liquid-metal cooling; ablation and sublimation coatings. Shown is an artist's rendering of an insulating, composite material made up of extremely thin layers of metal and ceramics which promises to be very efficient in protecting against high-heat environments. Development of such systems is considered at Lockheed to be an integrated relation of materials, environment and design.

METALLURGY

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

Metallurgy is typical of Lockheed Missiles and Space Division's broad diversification. The Division possesses complete capability in more than 40 areas of science and technology—from concept to operation. Its programs provide a fascinating challenge to creative engineers and scientists. They include: celestial mechanics; computer research and development; electromagnetic wave propagation and radiation; electronics; the flight sciences; human engineering; magnetohydrodynamics; man in space; materials and processes; applied mathematics; oceanography; operations research and analysis; ionic, nuclear and plasma propulsion and exotic fuels; sonics; space communications; space medicine; space navigation; and space physics.

Engineers and Scientists—Such programs reach far into the future and deal with unknown and stimulating environments. It is a rewarding future with a company that has an outstanding record of progress and achievement. If you are experienced in any of the above areas, or in related work, we invite your inquiry. Please write: Research and Development Staff, Dept. C-16, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense clearance required.

Lockheed

MISSILES AND SPACE DIVISION

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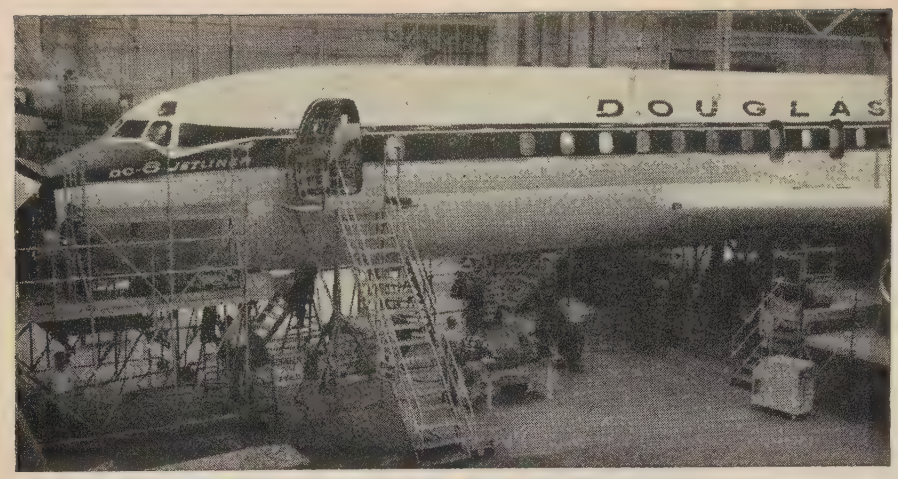
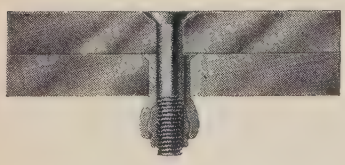


HOW Blind Nuts* SAVE MANHOURS ON THE DC-8



BN360 BLIND NUT

The Blind Nut was selected by cost conscious Douglas engineers for use as a nutplate to attach the diaphragm seal retainer strips on all exterior passenger doors and emergency exit jambs of the cabin-pressurized DC-8 luxury airliner because of its simpler and faster installation.

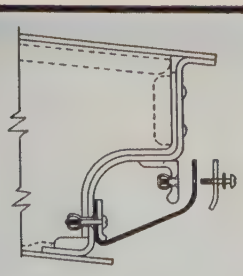
Each Blind Nut is installed in a single hole, in one operation and at a rate of about ten per minute compared to two additional countersunk holes required for the installation of two rivets to attach each nutplate.

Considering that each door on the DC-8 uses several hundred or more Blind Nuts, a substantial number of manhours will be saved on each production airplane when compared to the additional drilling and riveting time required to install conventional nutplates.

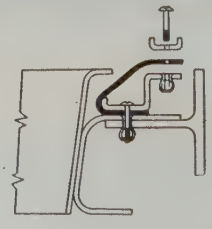
Stainless steel Blind Nuts are being used on aircraft and missiles in temperatures up to 800° F. in production and repair applications. They are quietly installed with a hand-held, hydraulically actuated gun. Blind Nuts are available in grip lengths of 1/16" increment and range in screw sizes from 4-40 through 3/8-24.

Write for additional Blind Nut data.

U. S. PATENT PENDING, FOREIGN PATENTS GRANTED AND PENDING *TRADEMARK



EXTERIOR PASSENGER DOOR INSTALLATION



EMERGENCY EXIT DOOR JAMB INSTALLATION

hi-shear RIVET TOOL COMPANY
2600 WEST 247TH STREET • TORRANCE, CALIFORNIA

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TOGGLE SWITCH is miniaturized

This miniaturized two-position toggle switch, designated 2TM1-T, measures ½ in x ½ in at the base and weighs 4½ grams. Integral terminals, gold-plated stationary contacts and a high contact force give it a low circuit resistance, and dependable operation is furnished in a temperature range of —65 deg to +200 deg F according to **Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill.** A threaded bushing with keyway slot provides single-hole mounting.

Contact arrangement is double-pole double-throw. Electrical rating is 7 amps, resistive, at sea level and 75,000 feet.

Write in No. 427 on Reader Service Card

SERVO CLAMP in two sizes

This clamp, part #2014, is for mounting motors, potentiometers, osynchros, and other types of servo style components. It is available in two sizes which accommodate a range of rotating shaft units, says **Precision Mechanisms Corp., Dept. S/A, 577 Newbridge Ave., East Meadow, N. Y.** The slotted design provides easy engagement and broadens the area in which the hold-down screw may be placed.

The wedge shape and use of 18-8 corrosion resistant steel provide high holding capacity. Requirements of MIL-E-5400 are fulfilled.

Write in No. 428 on Reader Service Card

COMPARATOR is transistorized

A compact transistorized voltage comparator for instant go/no-go indication of voltage tolerance checks any voltage from ±0.001 to ±999.9 v, according to **Non-Linear Systems, Inc., Dept. S/A, Del Mar, San Diego, Calif.** Within 90 milli-seconds the NLS 50 gives a clear "go" or "no-go" indication of voltage tolerance by means of colored lights.

It has a detection threshold of 500 micro-volts, a sensitivity of 0.005 per cent and its limit settings are precise to ±0.01 per cent.

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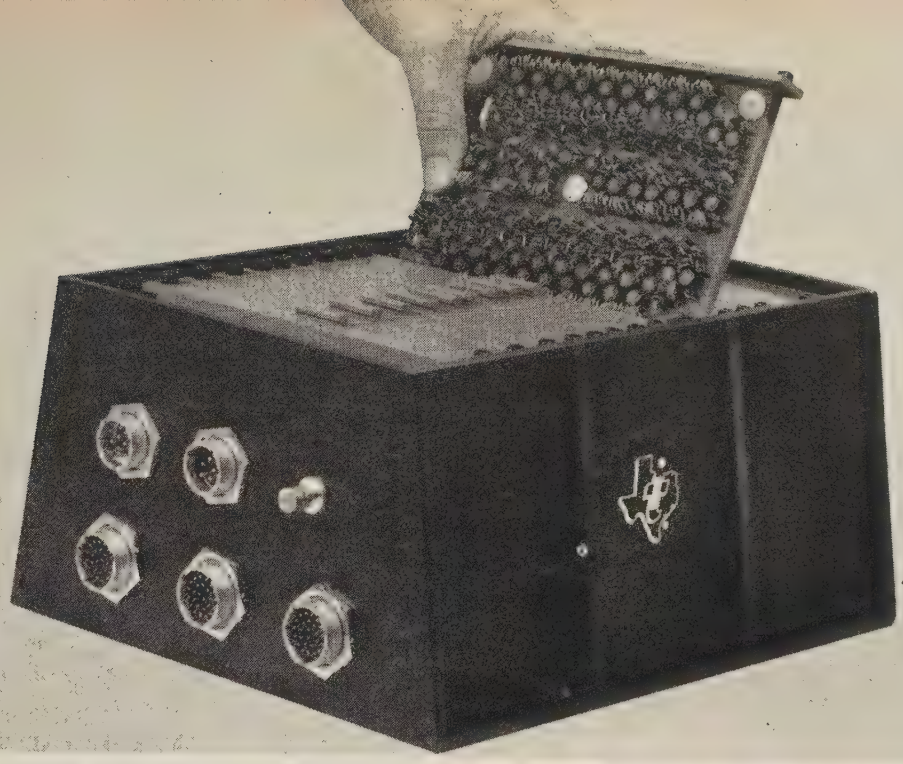
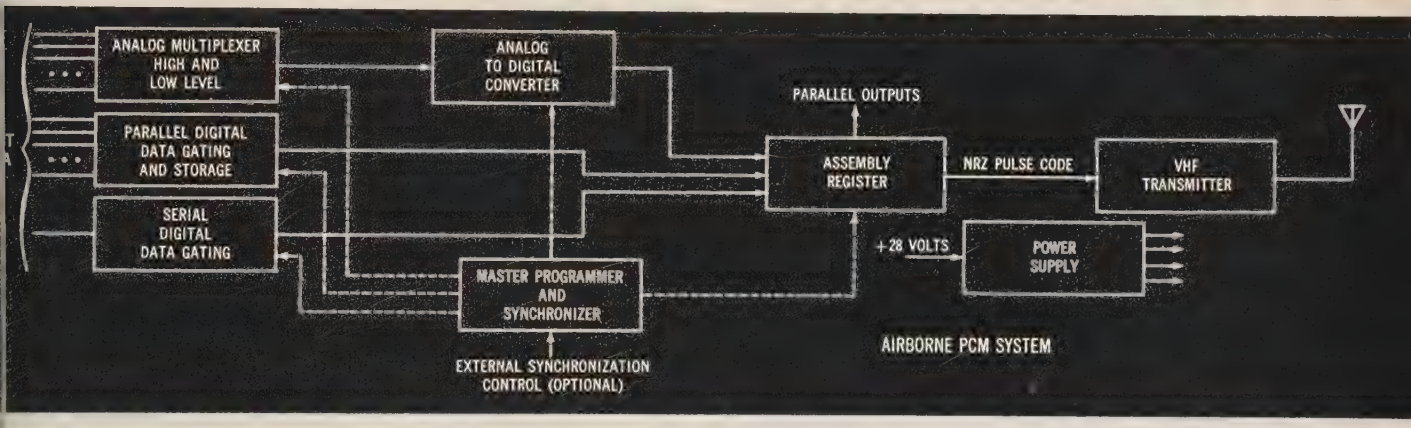
more on page 199



IEW FROM TEXAS INSTRUMENTS!



igh capacity, ½ cu ft, PCM telemetry system .with system drift nulled out!

v you can get the benefits of digital techniques ccuracy, speed and reliability — in compact pulse e modulation telemetry systems from Texas Instru- ts. The 25-pound, ½ cubic foot package shown only solid state devices, and may be used to drive of the compact TI transmitters dictated by the lication. The system multiplexes and encodes 64 log channels; and processes five 8-bit parallel tal data channels plus a serial digital data channel nominal bit rate of 200 kc.

key feature of the system is its high-speed analog tiplexer which handles low- and high-level data, combination of both, with *only a single low-level amplifier*. Overall accuracy of the system is ±0.25% — made possible by a unique bi-directional servo loop that nulls out system drift. The system is packaged in individual modules so that it can be rapidly modified to fit the needs of other missiles or space vehicles.

PCM is only one of several advanced telemetry projects at Texas Instruments. Others include the development and/or production of analog systems and equipments for Bomarc, Corvus, Pershing, Minuteman, Titan, Centaur, and Project Mercury.

For detailed information about PCM telemetry or other TI missile electronic system capabilities, please contact SERVICE ENGINEERING:

TEXAS INSTRUMENTS
INCORPORATED
APPARATUS DIVISION
6000 LEMMON AVENUE
DALLAS 9, TEXAS

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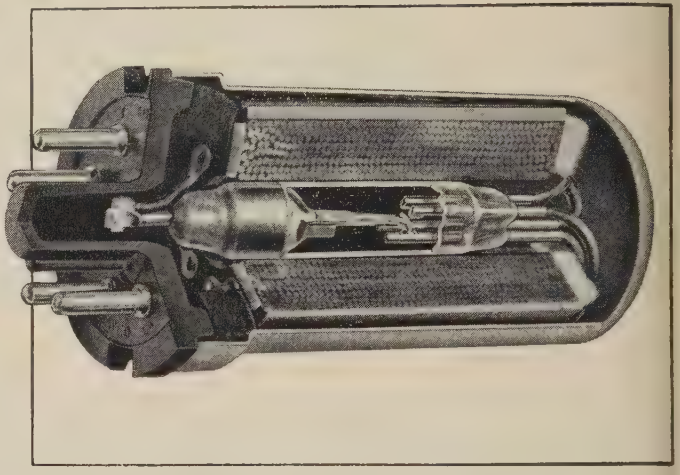
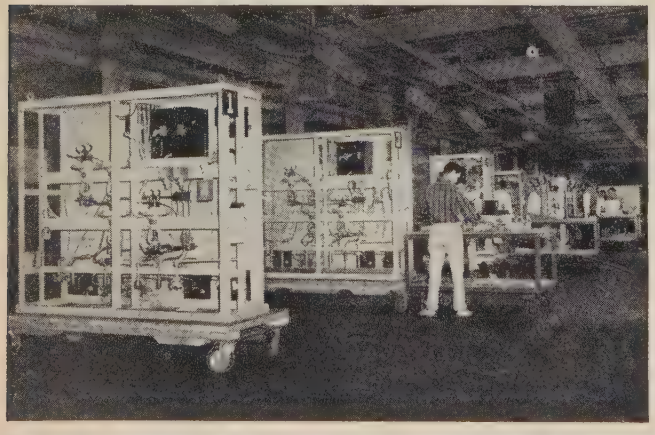
C. P. CLARE'S MERCURY-WETTED CONTACT RELAYS PERFECTLY SEALED WITH GLASS-TO-METAL SEALING ALLOY

C. P. Clare & Company, Chicago, Illinois, produces a complete line of mercury-wetted contact relays characterized by long life, high speed of operation and no contact bounce. To supply relays that have a conservative life expectancy of more than a *billion* operations requires absolute perfection in all phases of manufacturing. C. P. Clare uses BISHOP's #52 alloy tubing for the critical tubular stems of these relays. Mercury and hydrogen at 150 psig are introduced through this connecting stem—which is then sealed off by welding and forging. Can glass-to-metal sealing alloys solve any of your problems? BISHOP makes a complete line . . . use the coupon for details.



TUBING TAKES 5,400 PSI IN HONEYWELL'S MISSILE CHARGING SYSTEM



Super pressure stainless steel tubing connects many components of the cubicles illustrated. Minneapolis-Honeywell's Missile Equipment Division, Pottstown, Penna. builds these control cubicles that make up the gas charging system for the Bomarc missile. BISHOP supplies Honeywell with two sizes of 304 seamless super pressure tubing for this application. During charging of the missile, tubing handles pressures up to 5,400 psi. If you use small diameter tubing—super pressure, commercial quality or other—consider BISHOP. Use the coupon for a copy of BISHOP's Tubular Products Bulletin.

J. BISHOP & CO.
platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ Glass-To-Metal Sealing Alloy Data
- ☐ Tubular Products Bulletin No. 12
- ☐ Special Tubing Data
- ☐ Platinum Products Catalog No. 4

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Tubular Products Division
50 KING STREET, MALVERN, PENNA.
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THIS IS THE BISHOP LINE:
Products of all the Platinum Metals...
Small diameter Stainless Steel, nickel and special alloy tubing

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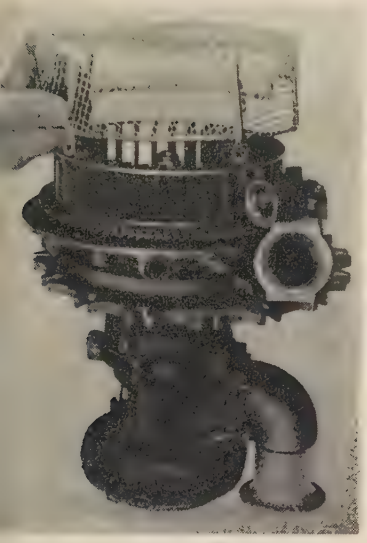
Write in No. 180 on Reader Service Card for Tubing

FUEL PUMP
has overspeed control



This fuel transfer pump provides ecific quantities of fuel at various itudes and is driven by compressor eed air. It has its own overspeed ntrol requiring no linkages or elec- cal power supply, says **Curtiss- right Corp., Dept. S/A, P. O. Box 9, Santa Barbara, Calif.** The unit n run dry without lubricant for ex- nded periods without damage, it is d.

Rated fuel flow is 10,000 lb per ur at any altitude from sea level to ,000 ft. Air flow is less than 6 lb r min and maximum environmental nperature is 250 deg F. It weighs lb, is 10 in high with a maximum meter of 7¾ in.

Write in No. 430 on Reader Service Card

SERVICING NOZZLE
for propellants

These nozzles and adapters for eling operations prior to countdown capable of transferring any exotic els and oxidants except those re- iring stoneware transmission equip- nt. For "closed circuit" fueling erations, two nozzles are required transfer propellant or oxidant m the supply source to missile and erflow venting from missile to rces. The three-way locking action tween the nozzle and its companion apter, permanently mounted on pply source and missile, absolute d and hazard-proof seal is effected, cording to **Lear, Inc., Dept. S/A, ria, Ohio.** Operation is satisfactory temperatures ranging from —65 to plus 140 deg F.

Originally designed to accommo- e fuming red nitric acid, only the er and more advanced aluminum l stainless steels are used for their rall resistance qualities to the cor- ive action of oxidants.

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more on next page

ite in No. 181 Reader Service Card

LOOK INTO CEC CONNECTORS

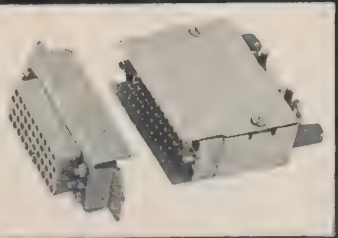
. . . see why they're guaranteed to give you highest reliability

The only thing you can't see for yourself is CEC's design and manufacturing experience in multi-contact rectangular connectors with snap-in contacts. That experience is well represented in the following features:

- Portal-hood speeds final assembly, permits full inspection of interior.
- Firmly attached cable clamp secures all wires to each other and to the connector.
- Jackscrews lock plug and receptacle together to withstand 50 g shock and cycling from 54 to 2,000 cps.
- Sturdy hood holds the insulator block... houses and protects the mated connector.
- Insulator block has deeply recessed contact openings and an unusually long insulation creepage path.

Yes, we can deliver. The 50-contact unit shown here is among many CEC types with 26, 34, 42, 50, 75 and 104 contacts.

For complete information, write for Bulletin CEC 4004-X23. Ask about CEC connector designs to your exact requirements.



Four-prong retention springs on pin and socket allow each contact to snap into insulator blocks easily, yet resist an axial pull of more than 20 lb. Inspection holes provide built-in quality control, permit visual checking of each wire for proper contact prior to assembly of connector.

Electro Mechanical Instrument Division

CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

Bendix-Pacific Radar Set AN/APS-88 is a lightweight, high sensitivity, multiple function radar for ASW and allied functions.

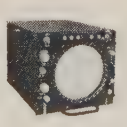
FOR ASW — Used in conjunction with IFF and sonobuoy systems the AN/APS-88 integrates signals into an overall PPI display which shows the presence of unfriendly aircraft, submarines and marine objects.

FOR WEATHER WARNING — Detection of cloud formations and mapping of storm fronts.

FOR SEARCH — Indicates even small objects — life rafts, life boats, and trawlers—as well as shore lines, islands and other marine topography.

AN/APS-88, developed by Bendix-Pacific for use on the U.S. Navy S2F-3, provides ranges from 3 to 240 miles and is operable to 30,000 feet. Maximum weight is 215 pounds. The set's unique sensitivity is achieved by varying pulse lengths and repetition rates for each selected target. Bendix-Pacific engineers are always available to discuss your airborne radar problems with you.

MORE PERFORMANCE PER POUND


AZIMUTH AND RANGE INDICATOR

ANTENNA

RECEIVER-TRANSMITTER

We invite your inquiry regarding the excellent opportunities for engineers now available. Write Ralph Lamm, Director of Engineering.

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION
NORTH HOLLYWOOD, CALIFORNIA

Check Employment Inquiry Form on Page 165

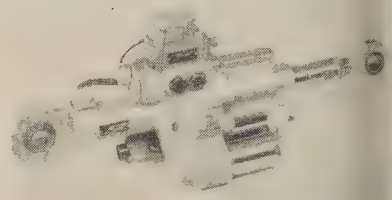
PORTABLE TESTER for circuit breakers

This portable high-current tester has built-in instrumentation for servicing current-actuated protective devices. It is designed primarily for testing air circuit breakers and oil circuit breakers. Other applications include CSP transformer breakers, motor overload relays, and current transformers, says **Multi-Amp Electronic Corp., Dept. S/A, Union, N. J.** Timer measures elapsed time of test from 0.01 second or 0.25 cycles, totalizing to 60 seconds, also measures in minutes and totalizes to 60 minutes.

The 4.5 in ammeters are accurate to ±2 per cent and have a pointer pre-set mechanism.

Write in No. 432 on Reader Service Card

SERVOACTUATORS are electrohydraulic



This series 17 servoactuator is an integrated hydraulic package which typically includes electrohydraulic servovalve, a cylinder-piston assembly and an electrical feedback device. Unit is designed for specific system application and may include special auxiliary devices such as pressure limiters, snubbers, flow limiters, piston locks, solenoids and/or integral filters to simplify systems installations, says **Moog Servocontrols, Inc., Dept. S/A, E. Aurora, N. Y.**

Typical models are operable to 350 deg F; special models can be designed for hydraulic control up to 600 deg F.

Write in No. 433 on Reader Service Card

VACUUM PUMPS are compact

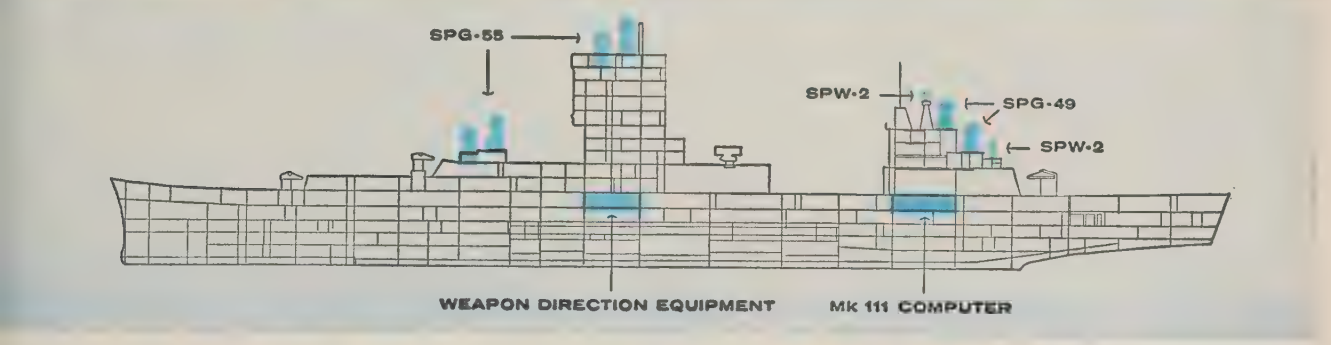
A series of compact oil-diffusion pumps having high pumping speeds and minimum backstreaming characteristics, including a purifying diffusion model and a 300 cfm mechanical booster, are produced by **NRC Equipment Corp., Dept. S/A, Newton, Mass.** The oil diffusion pumps include 2 in and 10 in models, H2SP and H10SP.

Speed of the 2 in model is 80 liters per second (170 cfm) at 0.1 micron Hg. The overall height is 10 in and projected floor area 11x3½ in. The H10SP model is said to have rated pumping speed of 2600 liters per second and an ultimate pumping pressure of 5×10^{-7} mm HG.

Write in No. 434 on Reader Service Card

more on page 204

.aboard the Navy's first nuclear-powered cruiser, the Long Beach



Fire Control by SPERRY

hen the Navy's first nuclear-powered face ship—the USS LONG BEACH—joins fleet, she will have a cruise capability better than 30 knots, with virtually imited range, and she will be armed h the surface-to-air Talos and Terrier ssiles. The most advanced ship of her d, the "CGN-9" will have the most vanced shipboard missile control ipment: Sperry.

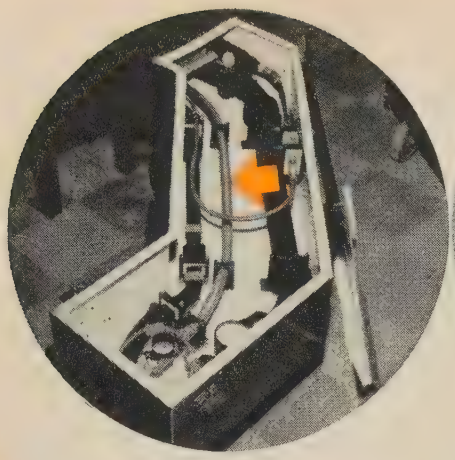
Forward, Sperry SPG-55 missile-dance radar directs the Terrier mis-. Aft, Sperry SPG-49 super-radar controls the longer range Talos missile. Amidships, and in the protected below deck region, are the brains of the systems, the computer complex. The Sperry Weapon Direction Equipment (WDE) evaluates target threat and decides which missile to fire at the selected target. The Sperry Mk 111 computer reads target position data from the SPG-49, calculates the best missile-to-target flight path, and positions the guidance beam generated by the Sperry SPW-2 Radar. Then it evaluates "kills."

With her combination of speed, range, firepower, and advanced Sperry fire control and navigation equipment, the LONG BEACH will make a formidable argument for peace when she joins the fleet.

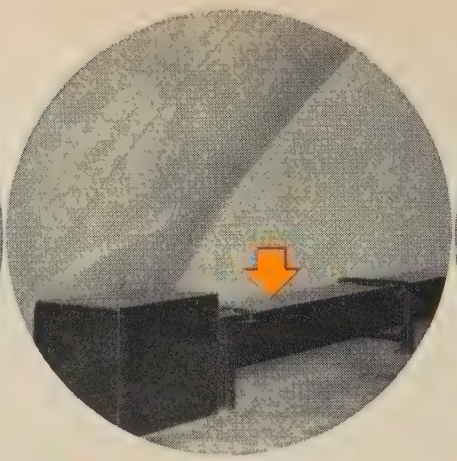
SPERRY

RFACE ARMAMENT DIVISION, *SPERRY GYROSCOPE COMPANY, DIVISION OF SPERRY RAND CORPORATION, GREAT NECK, NEW YORK*

Write in No. 183 on Reader Service Card at start of Product Preview Section



1—Within the control blockhouse, 7/8" 50 ohm Styroflex® cable starts its run to the Titan launch Complex 16 at Cape Canaveral . . .

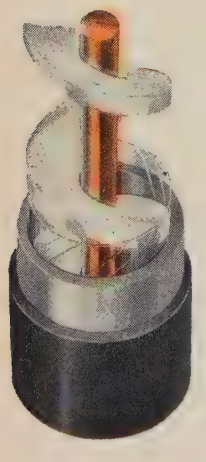


2—Following along the domed wall of the concrete blockhouse inside a protective case . . .

3—To the conduit that carries the high frequency cable through the massive concrete wall.

Styroflex® Coaxial Cable

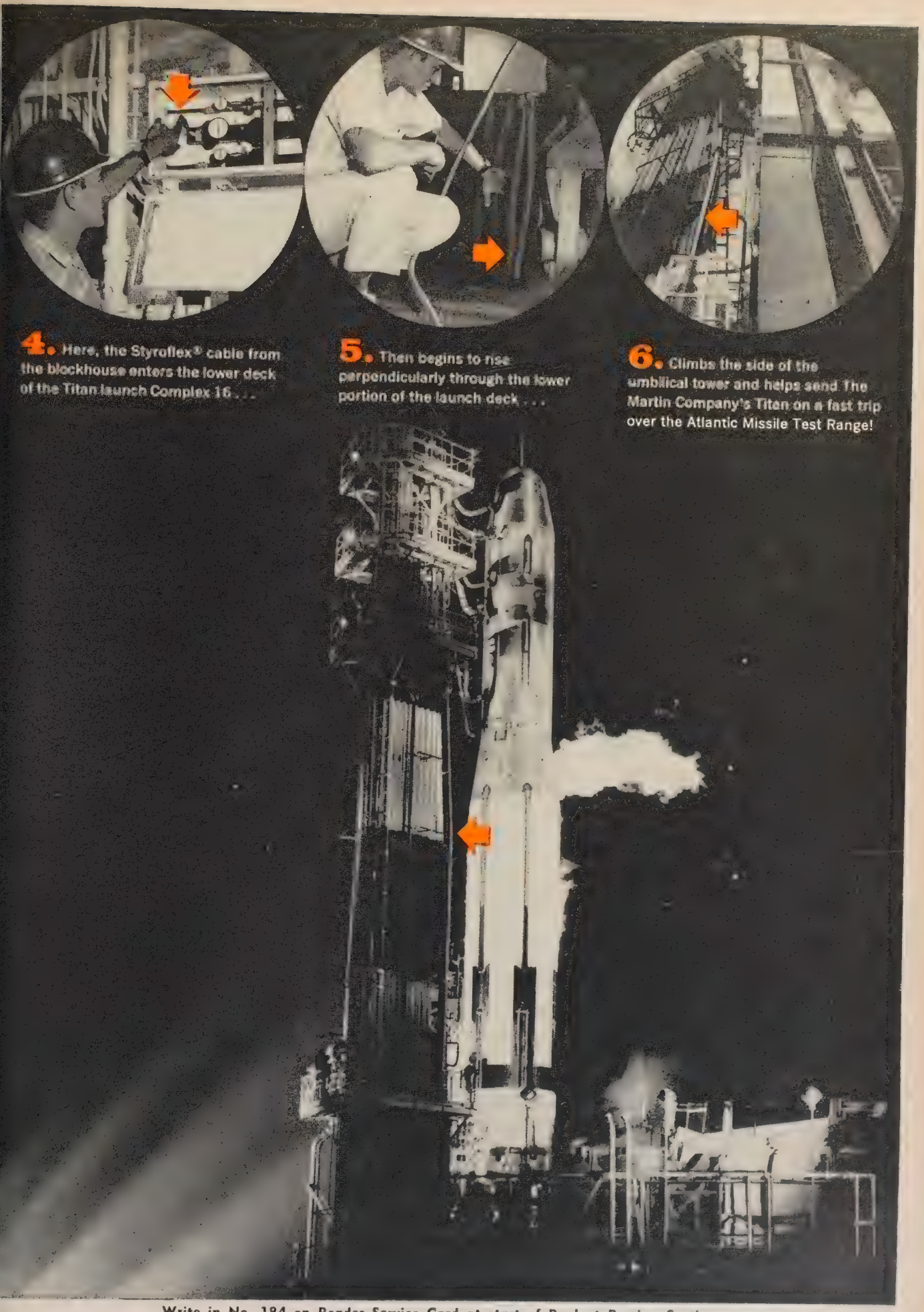
helps put the USAF Titan ICBM into space



The selection of Styroflex® air dielectric cable for use in the missile field was based on its superior electrical properties, uniformity, rugged physical qualities, long lengths that can be pulled up a tower without splicing and the elimination of radiation always present in braided coaxial cables. ■ Already proven in scores of applications, including broadcast, radar, missile tracking and tropospheric systems, Styroflex® cable has a long record of successes since its introduction in Europe in 1937. ■ Next time you have requirements for a high frequency cable with low attenuation and an extremely low inherent noise level, check the qualifications of Styroflex®. Just write Phelps Dodge.

PHELPS DODGE COPPER PRODUCTS
CORPORATION
300 Park Avenue, New York 22, N. Y.

PD



4. Here, the Styroflex® cable from the blockhouse enters the lower deck of the Titan launch Complex 16 . . .

5. Then begins to rise perpendicularly through the lower portion of the launch deck . . .

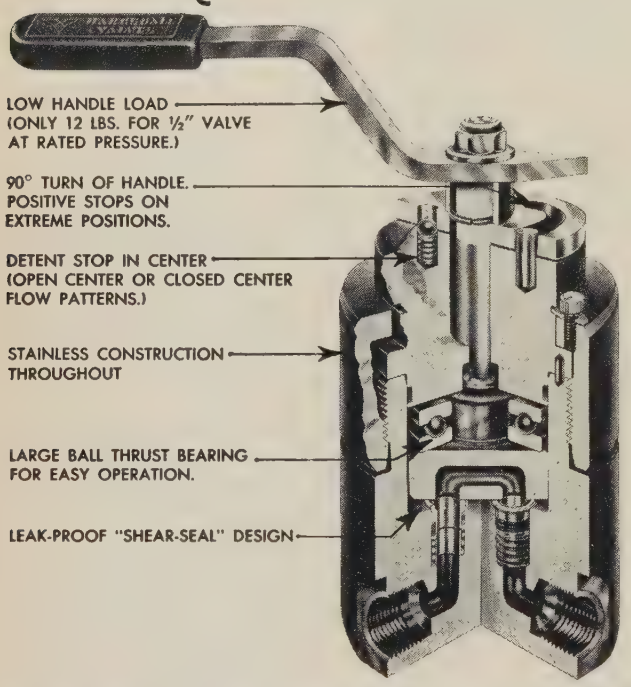
6. Climbs the side of the umbilical tower and helps send The Martin Company's Titan on a fast trip over the Atlantic Missile Test Range!

Write in No. 184 on Reader Service Card at start of Product Preview Section

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 58-59

CONTROL VALVE DIVISION

barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Write in No. 185 on Reader Service Card

CLUTCHES & BRAKES have fast response

These magnetic clutches and brakes for use in servo and control systems, analog computers, and precision instrumentation, include nine models in five frame sizes. Torque ratings in the field range from 6 in oz (size 5) to 224 in oz (size 18), with power consumption ranging from 2.5 W to 5. W, according to **Dynamic Instrument Corp., Dept. S/A, 59 New York Ave., Westbury, N. Y.**

They are said to provide fast response time and to meet all applicable military environmental tests.

Write in No. 435 on Reader Service Card

DC MOTOR is lightweight

The Model C-1360 dc motor is a lightweight, rectangular-type frame unit capable of producing .33 hp at 8400 rpm and .50 hp at 7700 rpm, and both ratings are for continuous-duty operation, says **Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif.** The unit is adaptable to a wide range of aircraft, missile and industrial applications such as pumps, compressors, gear boxes, and actuators.

The motor features a brush holder design that permits even brush pressure, low radio noise interference, high reliability, and long life. It weighs five lbs., is 6.5 in. long, 2.875 in. wide, and 3,125 in. high. The same frame is used for .20 to one-hp motors with speed ranges to 30,000 rpm, and models are available for operation to 500 deg and at over a 200,000-ft altitude.

Write in No. 436 on Reader Service Card

PRESSURE TRANSDUCER is miniature size

This miniature airborne pressure transducer of stainless steel construction permits measurement of corrosive fluid and gas pressures up to 1000 psi. Permanent bonding of the strain gages to the surfaces of the proving ring result in the resistance gages becoming an integral part of the sensing element, eliminating vibration effects on the gages, says **Taber Instrument Corp., Electronics Div., Dept. S/A, No. Tonawanda, N.Y.** The ring also provides a heat sink for the normal heating of the resistance gages and a conduction path in the instrument case.

It is said to have low sensitivity to vibration, infinite resolution, high overload capacity, and a pressure cavity clean-out feature.

Write in No. 437 on Reader Service Card

RELAY handles larger loads

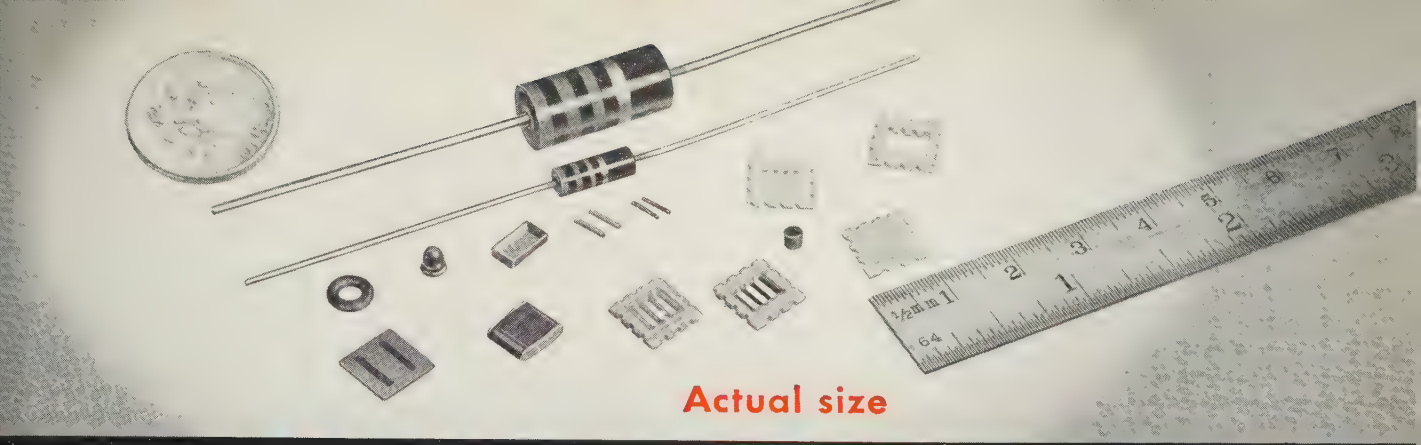
The JH-6D two-pole, subminiature, crystal relay can switch larger loads and resist higher-g values for shock and vibration than larger relays, says **Allied Control Co., Inc., Dept. S/A, 2 E. End Ave., New York 21, N. Y.** The 0.8-oz, 1 x 0.8 x 0.4-in device is rated for low level to five amps, and it is available with plug-in, printed circuit and hook-type solder terminals.

Sensitivity of the relay permits its use in plate circuits of tubes, or with transistors. The device can be adjusted to pull in as low as 100 mw with a maximum contact rating of two amps, non-inductive, at 29 V dc or 115 V ac. Operate time is ten msec max and release time five msec maximum. Ambient temperature range is –65 to +125 deg C.

Write in No. 438 on Reader Service Card

more on page 208

Write in No. 186 on Reader Service Card

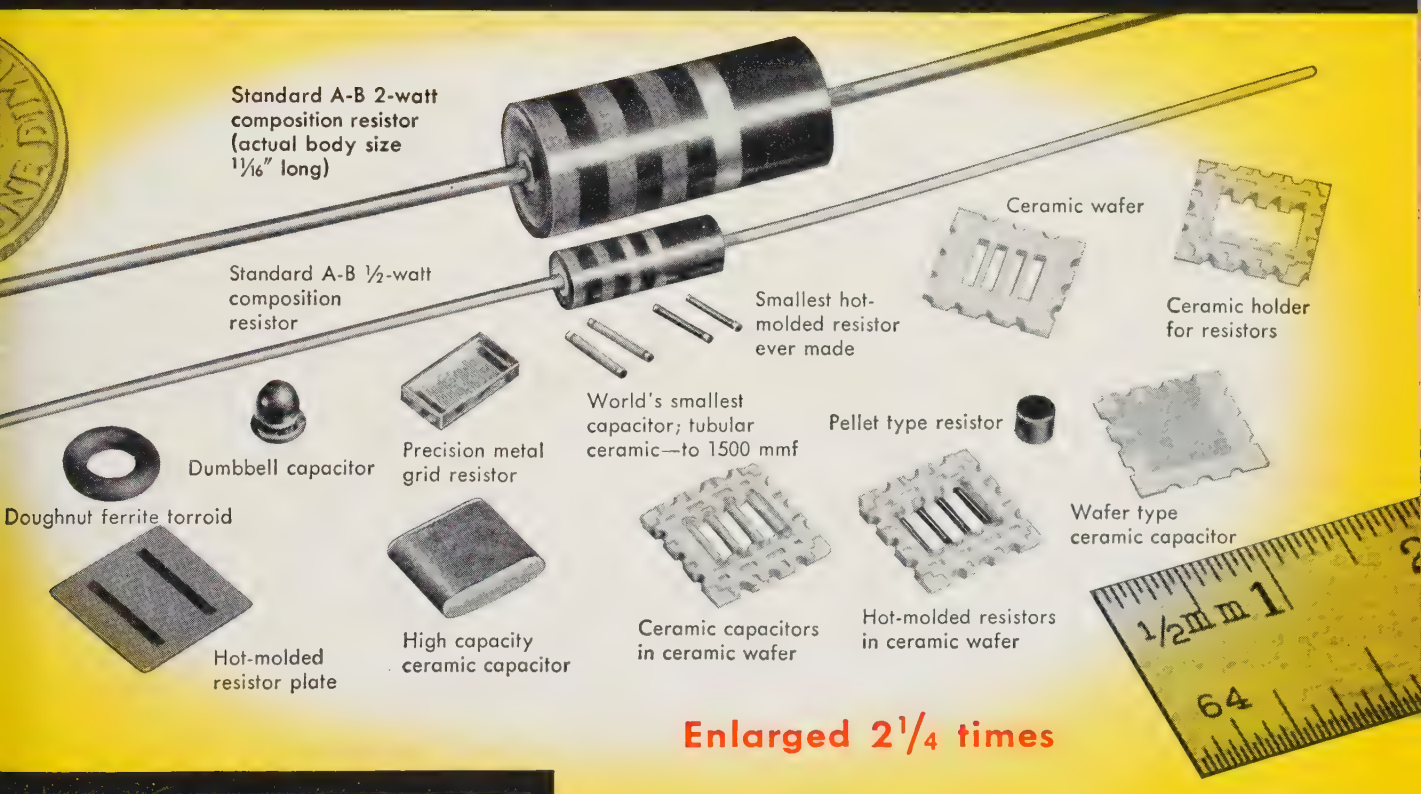


Actual size

Micro-Miniature Components

with traditional Allen-Bradley Reliability

A-B QUALITY


Standard A-B 2-watt composition resistor (actual body size 1 1/16" long)
Standard A-B ½-watt composition resistor
Smallest hot-molded resistor ever made
Ceramic wafer
Ceramic holder for resistors
World's smallest capacitor; tubular ceramic—to 1500 mmf
Pellet type resistor
Dumbbell capacitor
Precision metal grid resistor
Doughnut ferrite torroid
Wafer type ceramic capacitor
Hot-molded resistor plate
High capacity ceramic capacitor
Ceramic capacitors in ceramic wafer
Hot-molded resistors in ceramic wafer

Enlarged 2 1/4 times

ALLEN-BRADLEY

Quality

Electronic Components

Allen-Bradley has developed a variety of remarkable micro-miniature components. These components include standard types for wafer configurations, as well as several unique units which would seem to hold extremely interesting possibilities for future developments. In addition, A-B research has succeeded in removing the major hurdle in connection with consistent "reliability." This permits the production of fantastically small components. For example, the hot-molded resistors for wafer mounting are only 0.155" long and 0.025" in diameter.

These achievements in the field of micro-miniature components typify the advanced engineering at Allen-Bradley. Naturally, we'll be very happy to help you with your miniaturization problems.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

1-40.5

HEAT PROBLEMS?

New Type L Potentiometer Actual Size

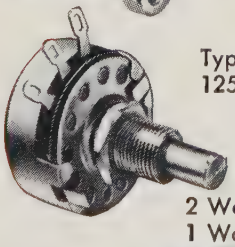
Allen-Bradley POTENTIOMETERS for HIGH TEMPERATURE APPLICATIONS

...up to 150°C!

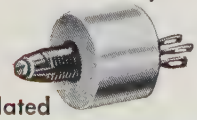
ADDITIONAL ALLEN-BRADLEY HIGH TEMPERATURE POTENTIOMETERS

Type L
½ Watt at 100°C

Type L with 125v Line Switch



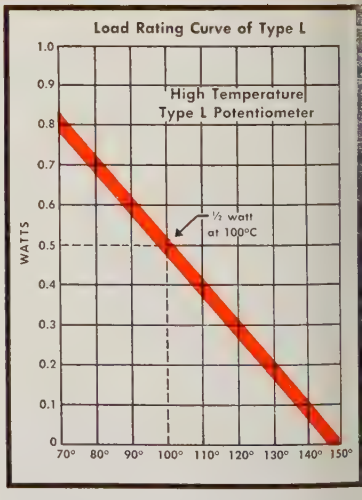
Type K
2 Watts, 100°C;
1 Watt, 125°C



Type L Encapsulated

This new Allen-Bradley potentiometer—the Type L—is especially designed to solve problems associated with high ambient temperatures—*and* space conservation. Although extremely compact—0.5 inch in diameter—the Type L control has a conservative rating of 0.5 watt when operating in an ambient temperature of 100°C. And, it provides reliable performance when operated at a temperature of 150°C—under "no load" conditions. (See graph at right.)

The new Type L control features the same solid, *hot molded* resistance element that has proved unequaled for long life, smooth operation, and low "noise" characteristic in Allen-Bradley's popular Type J, Type K, and Type G potentiometers. When temperature and space problems in your designs plague you, this new A-B "high temperature" potentiometer is a reliable answer. Please send for complete information, today.



AMBIENT TEMPERATURE °C.

Load Capabilities of Type L below the Critical Resistance Value. Type L Far Exceeds the Requirements of MIL-R-94B.

ALLEN-BRADLEY

Quality Electronic Components

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

1-60-E

igh Strength Fasteners of rmco 17-4 PH tainless Steel | Save Weight Resist Heat Prevent Corrosion

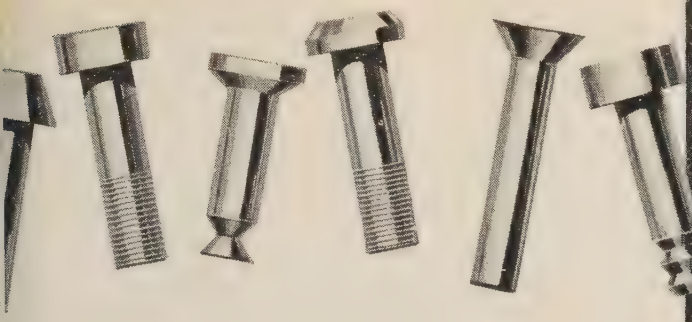
For bolts, pins, rivets and other mechanical fasteners, Armco's Precipitation-Hardening Stainless Steel offers mechanical properties that effectively meet the rugged requirements of missiles and jet-powered aircraft.

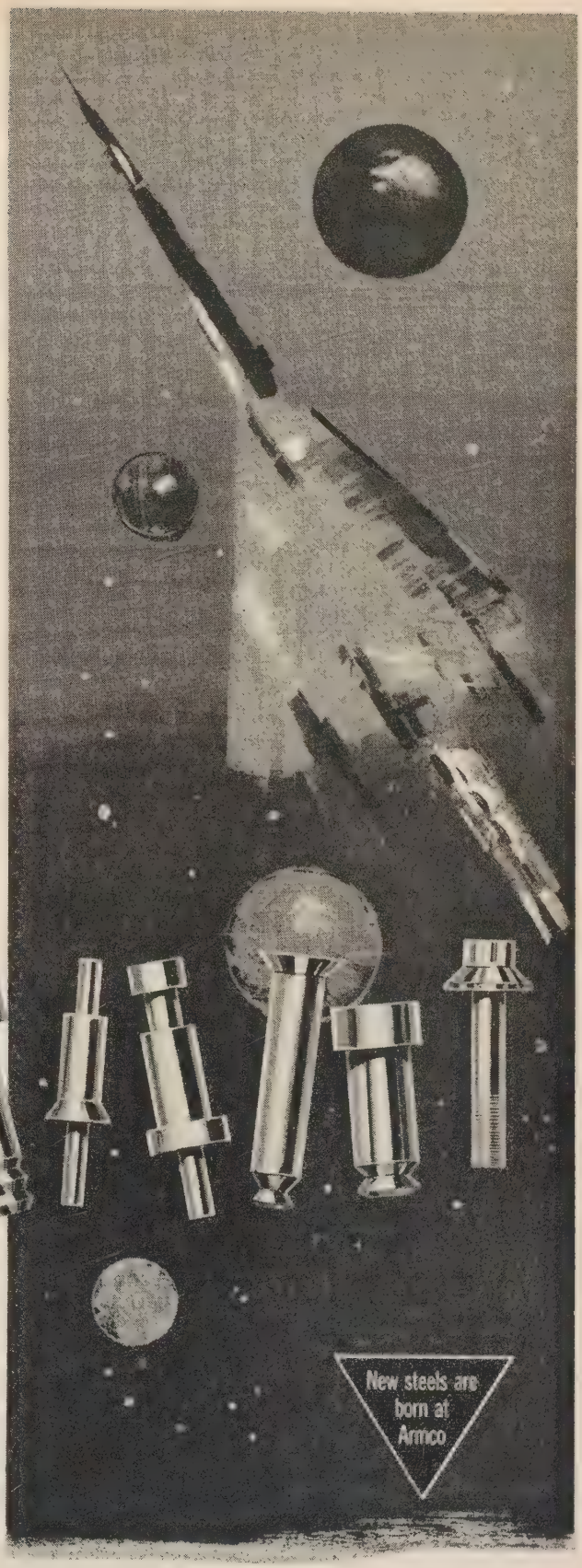
Tensile strengths to 200,000 psi permit high-torque, lightweight, efficient connections.

High strengths up to 700 F provide reliability in hot spots.

Excellent corrosion resistance insures durability without plating problems.

Good fabricating characteristics and simple heat treatment speed production.





This high strength Armco Stainless Steel is utilized in military, commercial and research air vehicles to achieve high mechanical efficiency and reliability in special and standard fasteners. Consider how its properties can help you solve your fastener problems.

For complete information on Armco's Precipitation-Hardening Stainless Steels or any of our complete line of standard and special types of stainless, write Armco Steel Corporation, 1350 Curtis Street, Middletown, Ohio.

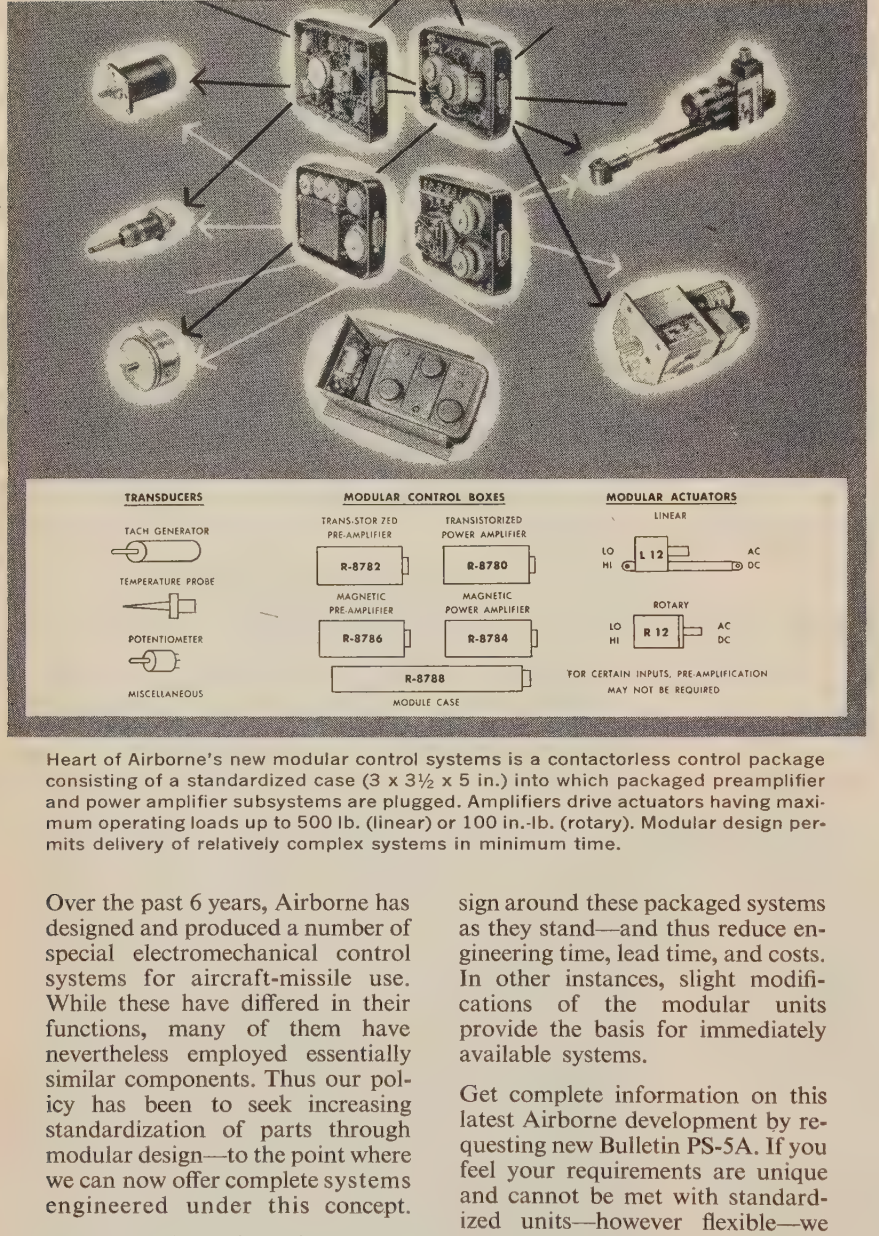
ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

Write in No. 107 on Reader Service Card at start of Product Preview Section

Now—Modular Control Systems

New Airborne concept saves design time, helps you get faster delivery



Heart of Airborne's new modular control systems is a contactorless control package consisting of a standardized case (3 x 3½ x 5 in.) into which packaged preamplifier and power amplifier subsystems are plugged. Amplifiers drive actuators having maximum operating loads up to 500 lb. (linear) or 100 in.-lb. (rotary). Modular design permits delivery of relatively complex systems in minimum time.

Over the past 6 years, Airborne has designed and produced a number of special electromechanical control systems for aircraft-missile use. While these have differed in their functions, many of them have nevertheless employed essentially similar components. Thus our policy has been to seek increasing standardization of parts through modular design—to the point where we can now offer complete systems engineered under this concept.

From transducer through actuator, these new Airborne systems are assembled entirely from standardized, interchangeable components. For many applications, you can design around these packaged systems as they stand—and thus reduce engineering time, lead time, and costs. In other instances, slight modifications of the modular units provide the basis for immediately available systems.

Get complete information on this latest Airborne development by requesting new Bulletin PS-5A. If you feel your requirements are unique and cannot be met with standardized units—however flexible—we still invite your inquiry. As mentioned, Airborne offers an extensive background in custom systems—for temperature control, servo control, and positioning.

AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

Write in No. 108 on Reader Service Card at start of Product Preview Section

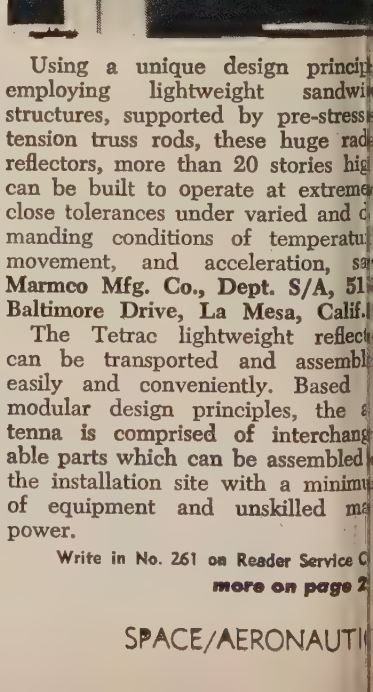
WAVEGUIDE COUPLE has quick disconne

Simplicity of operation is feature in the Model 3419 waveguide quic disconnect, a coupler that may b adapted to make connections on a types of waveguide components, in cluding most flexible application says **Aircraft Armaments, Inc., Dep S/A, Cockeysville, Md.** The devic suitable for field or laboratory us adds very little to the connection size and attaches to a standard chok flange by means of two screws.

The mounting screws assure prop alignment of the coupled waveguid sections, which are fastened togeth by clockwise rotation of the couple The device can connect two cov flanges as well as a choke and cov flange, a feature useful where th thickness of choke and cover flang differs. The Model 3419K is designe for K-band waveguide, the Mod 3419X for X-band.

Write in No. 260 on Reader Service Ca

HUGE RADAR REFLECTOR operate at close tolerance



Using a unique design princip employing lightweight sandwi structures, supported by pre-stress tension truss rods, these huge rad reflectors, more than 20 stories hig can be built to operate at extreme close tolerances under varied and c manding conditions of temperatu movement, and acceleration, sa Marmco Mfg. Co., Dept. S/A, 51 Baltimore Drive, La Mesa, Calif.

The Tetrac lightweight reflect can be transported and assembl easily and conveniently. Based modular design principles, the a tenna is comprised of interchang able parts which can be assembled the installation site with a minimu of equipment and unskilled ma power.

Write in No. 261 on Reader Service C

more on page 2

move it in . . . couple it . . . turn it on . . .

with a VICKERS® "packaged" unit power is instantly available to operate your missile-support system

Fast and easy installation is an important advantage of these "packaged" hydraulic power and control systems by Vickers. It saves time at the missile site — keeps "on-the-spot" labor charges low. That's important! Yet this fast installation is only one of the benefits you get with these factory-built power packages.

Save Design Time — Since 1932 Vickers has custom designed hydraulic power packages. Thus, we know how to avoid "false starts" and can develop highly efficient units *in a hurry.*

Eliminate Mismatching — Each power package contains compatible, balanced components all produced by Vickers. There are no hybrids — there is no need for "force fits".

Save Space — Units are surprisingly compact, yet all components are easily accessible. Solid steel drilled manifolds reduce piping and space. Components, lines and connections are kept to an absolute minimum.

Simple Field Adjustment — The building-block concept is followed to give component interchangeability, servicing ease and quick location of any malfunction. All components are individually tested; complete power units are pretested before shipment.

Insure Predictability — Vickers designs and builds systems which meet the most rigid performance specifications including predicted ambient temperature, weather and other conditions.

Reduce Field Inventory — As far as possible, units are designed with components that are commercial "shelf" items. Inventories of warehouse stocks can be kept low because of component and part interchangeability.

How far advanced is your project? If it is in the design and development stage, we can *immediately* place a team of hydraulic specialists in your plant to work with your engineers. If it is in the "breadboard" stage, let us give you an alternate proposal. On many applications we have suggested much improved power units at attractive production-line prices.

Write for Bulletin 5303
"Vickers Oil Hydraulics for Missile Systems"

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

DISTRICT SALES OFFICES: DETROIT, MICH. • EL SEGUNDO, CALIF. • MEDIA, PA. • SEATTLE, WASH. • WASHINGTON, D. C.

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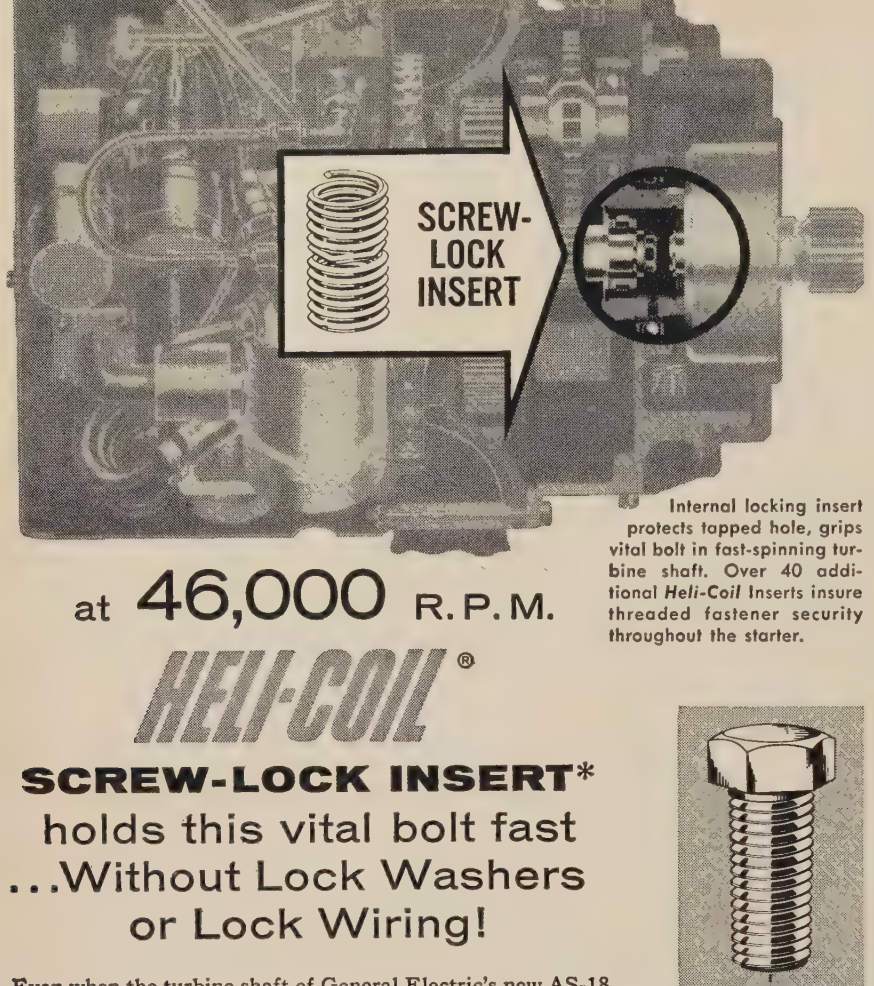
MO-215B



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* Inserts insure threaded fastener security throughout the starter.

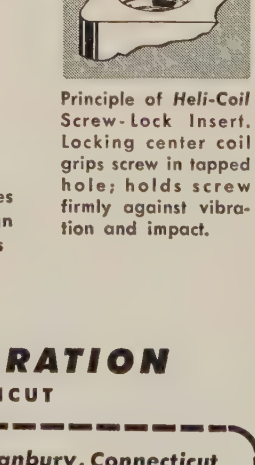
at 46,000 R.P.M.

HELI-COIL®

SCREW-LOCK INSERT*
holds this vital bolt fast
...Without Lock Washers
or Lock Wiring!

Even when the turbine shaft of General Electric's new AS-18 turbostarter whirls at 46,000 rpm... the key bolt at the end of the shaft can't work or wear loose. General Electric puts a one-piece, *internal locking* ***Heli-Coil*** Screw-Lock Insert in this tapped hole, gets thread security in this important threaded assembly despite vibration met at high shaft speeds.

In addition to the critical shaft application, General Electric uses more than 40 of these ***Heli-Coil*** stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring... lighter weight... less installation cost... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of *Heli-Coil* Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

***Heli-Coil* Screw-Lock Inserts**

- positively lock screws and bolts against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes
- save assembly time, space, weight and cost
- meet military specs for locking torque and vibration

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 103 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-Lock Inserts
NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____ 1772

Write in No. 110 on Reader Service Card at start of Product Preview Section

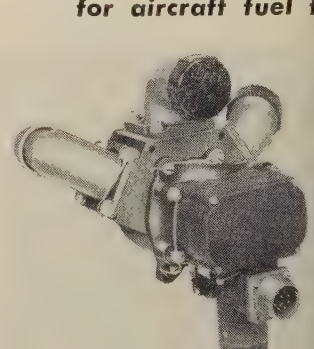
DC MOTOR FILTER withstands high temperatures

This 150 amp, 100 VDC radio interference filter will withstand continuous temperatures of 125 deg C, 150 deg C for 24 hours and 250 deg C for a period of 15 minutes. In addition to a continuous current rating of 150 amps, the filter will carry 300 amps for a period of one hour at 125 deg C, according to **Genistron, Inc., Dept. S/A, 2301 Federal Ave., Los Angeles 64, Calif.**

Mechanical and electrical characteristics meet MIL-M-8069 specifications for dc aircraft motors, and the radio interference characteristics of MIL-I-61 81B.

Write in No. 262 on Reader Service Card

SELECTOR VALVE for aircraft fuel tanks



This ball-type multiport fuel selector, No. 30-1748-000, interconnect any combination of aircraft fuel tanks. It can comprise a complete selector system by varying the number of ports and valve positions, says **Aeronautical Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** Able to handle all hydrocarbon fuels, the valve can be operated manually or by motor, selecting the tanks from which fuel is to be drawn by remote control.

Weight is 5.2 lbs, and it may be built in line sizes from ½ to 3 in. Operating pressure is 60 psi with a flow rate of 900 gph. It will operate at altitudes from 0 to 50,000 ft.

Write in No. 263 on Reader Service Card

SENSITIVE RELAY for low power circuits

This 2 milliwatt high sensitivity relay, series 300 microamp, is for low power input circuits. Applications include high speed keying, remote control or battery operated devices, says **Kurman Electric Co., Dept. S/A, 191 Newel St., Brooklyn 22, N. Y.** Field adjustable to handle currents of up to 3 amps at reduced sensitivity.

Plastic dust cover. Mounting, two .196 in clearance holes on 2⅛x2¼ centers.

Write in No. 264 on Reader Service Card

more on page 21

LEAR-ROMEC

makes the second best pumps in the world

Hydraulic piston pump power unit

hot Write for new **hydraulics** folder describing Lear-Romec high temperature, high speed, high pressure hydraulic pumps for aircraft.

LEAR **LEAR-ROMEC DIVISION** · Airbe Road · Elyria, Ohio

ENGINEERING REPRESENTATIVES IN ALL MAJOR CITIES IN THE UNITED STATES

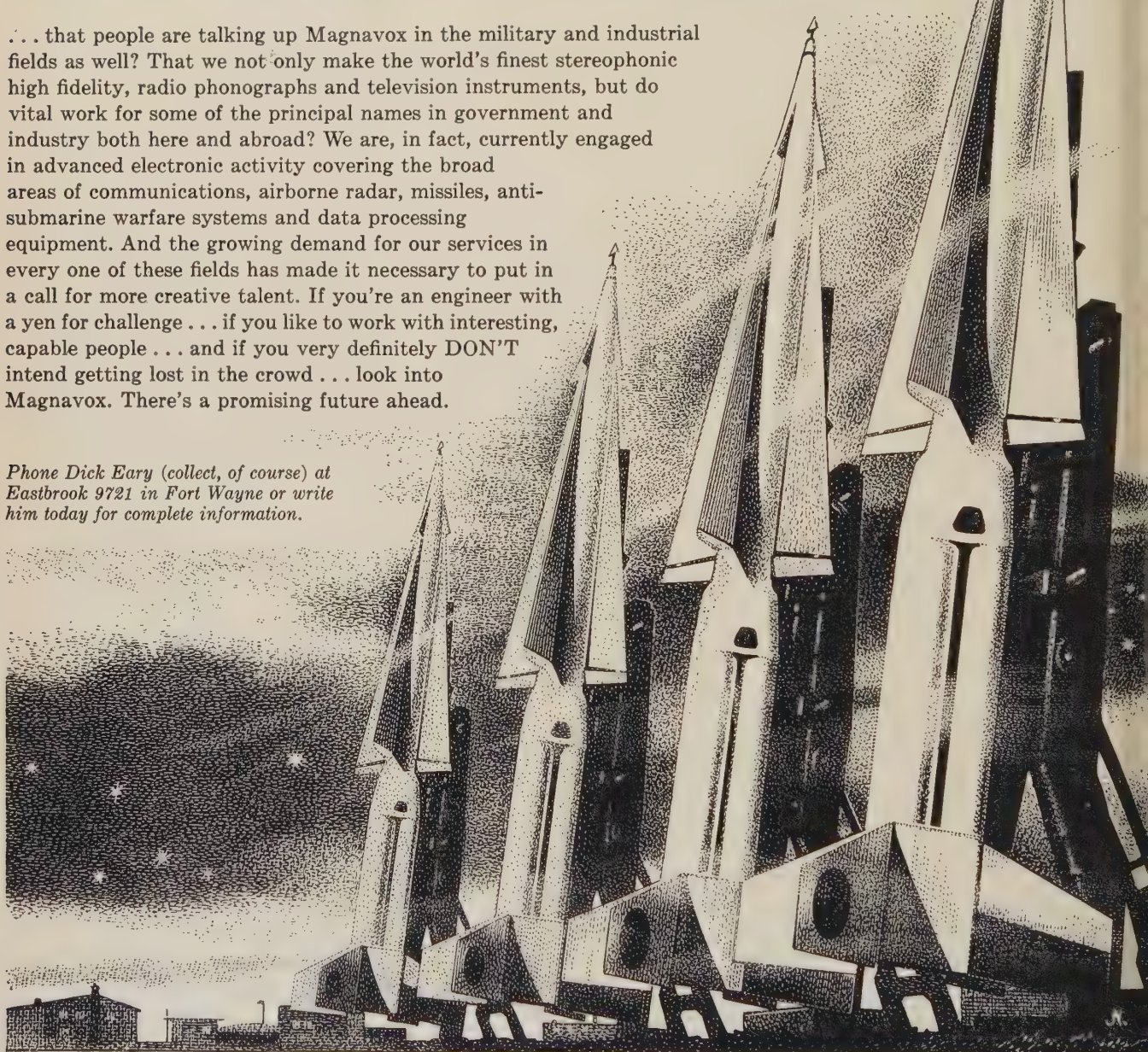
Write in No. 111 on Reader Service Card at start of Product Preview Section

Sure, we're proud of what they're saying in consumer circles...

BUT, MR. ENGINEER, DID YOU KNOW...

. . . that people are talking up Magnavox in the military and industrial fields as well? That we not only make the world's finest stereophonic high fidelity, radio phonographs and television instruments, but do vital work for some of the principal names in government and industry both here and abroad? We are, in fact, currently engaged in advanced electronic activity covering the broad areas of communications, airborne radar, missiles, anti-submarine warfare systems and data processing equipment. And the growing demand for our services in every one of these fields has made it necessary to put in a call for more creative talent. If you're an engineer with a yen for challenge . . . if you like to work with interesting, capable people . . . and if you very definitely DON'T intend getting lost in the crowd . . . look into Magnavox. There's a promising future ahead.

Phone Dick Eary (collect, of course) at Eastbrook 9721 in Fort Wayne or write him today for complete information.



FORT WAYNE, URBANA, ILLINOIS, LOS ANGELES, CALIFORNIA

Magnavox

COMMUNICATIONS

RADAR

DATA HANDLING

ASW

MISSILES

THE MAGNAVOX CO. • DEPT. 232 • *Government and Industrial Division* • FORT WAYNE, IND

Write in No. 112 on Reader Service Card at start of Product Preview Section

WE OFFER

ULTRA-PURE
YTTRIUM
HIGHLY DUCTILE

In Quantities
from Grams to
100 Lb. Lots

In Sponge Form
or in Ingots
1 Inch By 5 Inches.

ALSO

VERY HIGH
PURITY
CHROMIUM
POWDER

From Lb. Quantities
to Ton Lots.

Screen Cuts, 30
Mesh Down.

Gadolinium and other
rare earth metals of
high purity can be
produced on order.

LUNEX COMPANY
PLEASANT VALLEY,
IOWA

Write in No. 113 on Reader Service Card

DIGITAL COMPUTER
stores 128 words

Model SPEC is a completely modular and transistorized digital computer utilizing proven up-to-date high-speed digital circuitry. The command structure is well suited for teaching basic programing techniques. The unit is readily disassembled for class room inspection and then easily reassembled and put into operation without delay, according to **Computer Control Company, Inc., Dept. S/A, 2251 Barry Ave., Los Angeles 64, Calif.**

The unit can also be used for serious computation since it is a stored-program single-address machine with 128 words of fast access internal storage. All internal logical interconnections between the plug-in modules are effected via a removable plugboard patch panel. By replacing the general-purpose computer patch panel with the DDA panel, the unit is converted into a digital differential analyzer containing 20 integrators.

Write in No. 265 on Reader Service Card

COUPLING
for phasing synchros

This line of zero adjustable couplings type T-9 and T-10 provides precision rotational angular adjustment between two synchro rotors or other mechanisms requiring angular displacement. This is obtained by rotating one synchro rotor in respect to the other through the medium of this new adjustable coupling. Precision is possible since one turn of the coupling adjusting screw rotates one coupled shaft in respect to the other through only 12 deg, says **PIC Design Corp., Dept. S/A, 477 Atlantic Ave., E. Rockaway, Long Island, N.Y.**

A continuous rotational adjustment through 360 deg, in either direction, is another feature of this coupling. A screwdriver is the only tool needed. Length of coupling is 1.862 in. Overall diameter is $^{5}/_{64}$ in.

Write in No. 266 on Reader Service Card

more on page 215

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

SIZE 11
SYNCHRONOUS
MOTOR

Featuring pull out torque efficiency of 50% nominal with 3.4 watts input and 3 watts pull out power, this synchronous motor represents a major achievement in terms of performance for a unit of this extremely small size. Additional advantages made possible by Kearfott's unique design include resistance to environmental extremes, light weight construction and low unit cost. This motor and its variations are available in production quantities.

TYPICAL
CHARACTERISTICS R172

Excitation:	Phase 1	Phase 2
Voltage	40V	40V
Frequency	400 CPS	400 CPS
Power	2.3 Watts	2.3 Watts
Current	0.157 Amps	0.157 Amps

Performance:

Synchronous Speed	8000 RPM
Stall Torque	0.2 In. Oz.
Pull Out Torque	0.35 In. Oz.
Pull In Torque	0.15 In. Oz.

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY

Write in No. 114 on Reader Service Card

Flames swept across the open plains as the Mongol hordes ran in terror from the "arrows of flying fire". When the smoke had cleared the Chinese had won the battle of Pienking with the first rocket.

Missiles have become greatly more sophisticated since this crude unguided arrow was propelled by gunpowder packed in an open-ended bamboo tube. Today, as a vital part of one of the world's largest electronics companies, Raytheon's Missile Systems Division is making significant contributions to the art of missilry. The exciting new Pin Cushion Project for selective missile identification, the constantly advancing Navy's air-to-air SPARROW III and Army's HAWK are examples of their outstanding creative work.

We are seeking highly creative people to maintain Raytheon's leadership in this challenging field. For these people, Raytheon's Missile Systems Division creates a climate for talent — perhaps *your* talent.

MISSILE: 13th CENTURY

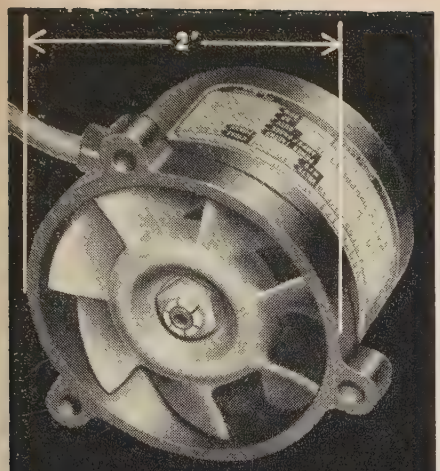
ENGINEERS: immediate openings in Data Handling — Circuit Design — Packaging—Electro-Mechanical Design—Systems Test — Test Equipment Design — Systems Analysis — High Power Radar Design — Microwave Tube Application — High Voltage Power Supply — Modulators — Microwave Design — Systems Design — VHF Circuit Design — Operations Analysis — Radar Systems and Mathematicians.

Please apply to Mr. W. F. O'Melia, Employment Manager, Bedford Laboratory, Missile Systems Division, Raytheon Company, Bedford, Massachusetts.

RAYTHEON MISSILE SYSTEMS DIVISION

... creates a climate for talent.

Check Employment Inquiry Form on Page 165



HIGH PERFORMANCE 2-Inch Cooling Fan

AiResearch Minifan* is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H_2O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- **Volume flow: 21.5 to 53.5 cfm**
- **Pressure rise: .6 to 3.44 H_2O**
- **Speed: 10,500 to 22,500 rpm**
- **Single, two or three phase power**
- **Power: 16 to 69 watts**
- **Standard or high slip motors**
- **Weight: .36 to .48 lb.**

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

*Minifan is an AiResearch trademark.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

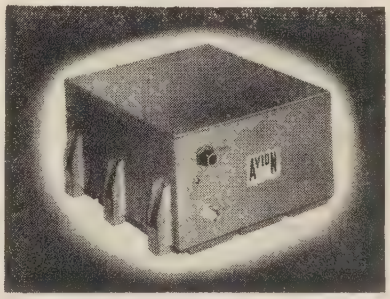
Write in No. 115 on Reader Service Card

UNIVERSAL GRINDER for hydraulic operation

A universal grinding machine with fully hydraulic operation, double swivel wheel head that permits simultaneous grinding of should and O.D., additional grinding wheel that can be mounted on wheel head for flange and similar grinding, supersensitive in-feed, automatic gaging and mating and automatic wheel dressing is announced as available by **Alina Corp., Dept. S/A, 122 E. Second St., Mineola, L. I., N. Y.**

Write in No. 267 on Reader Service Card

RADAR BEACON for c- and s-bands



Type 149 is a radar beacon designed as an airborne, pulse-type tracking aid for long-range missile or space applications. Completely transistorized except for the local oscillator and the transmitter, it features unusually high reliability and long life, and combines sturdy construction with small size, light weight and low power consumption, says **Avion Div., ACF Industries, Inc., Dept. S/A, 11 Park Place, Paramus, N.J.**

The single housing includes a transistor power supply for developing regulated operating voltages. The beacon operates in the C-Band or S-Band and responds to coded or uncoded pulse interrogations from radars.

Write in No. 268 on Reader Service Card

SOLENOID VALVE for helium, air, nitrogen

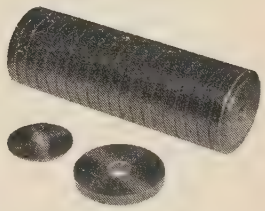
This solenoid operated shut-off valve, the No. 2785, acts as both shut-off valve and as a check-valve for reverse flow. As a shut-off valve it is normally closed and opens with application of 28 vdc to the solenoid, says **Interstate Engineering Corp., Dept. S/A, 600 East Vermont, Anaheim, Calif.** It is for use with helium, air or nitrogen and operates at a pressure of 3250 psi at a temperature range of —360 deg F to +160 deg F.

In use with helium under test conditions leakage is said to be zero.

Write in No. 269 on Reader Service Card

more on page 217

BASIC BUILDING BLOCKS FROM KEARFOTT



FERRITES

Kearfott's Solid State Physics Laboratory formulates, fires and machines permanent magnet ferrite materials of various compositions. Typical high-efficiency array utilizes Kearfott PM-3 ferrite material with specially designed pole pieces to produce a design both smaller and lighter than other arrays of equivalent magnetic field strength. Because magnets may be custom engineered to specific requirements, user is not restricted to stock magnet types, thereby providing greater latitude in parameters for focusing arrays. Pole pieces may also be provided according to specification, with the added assurance that, because of special Kearfott design techniques, B axial magnetic fields approximately 10% higher than those generally obtained in standard types may be produced.

TYPICAL CHARACTERISTICS

Peak Magnetic Field Strength	1200 gauss
Period	0.560 in.
Length	5.64 in.
Inside Diameter of Pole Pieces	0.400 in.
Outside Diameter	2.0 in.
Weight	3.2 pounds

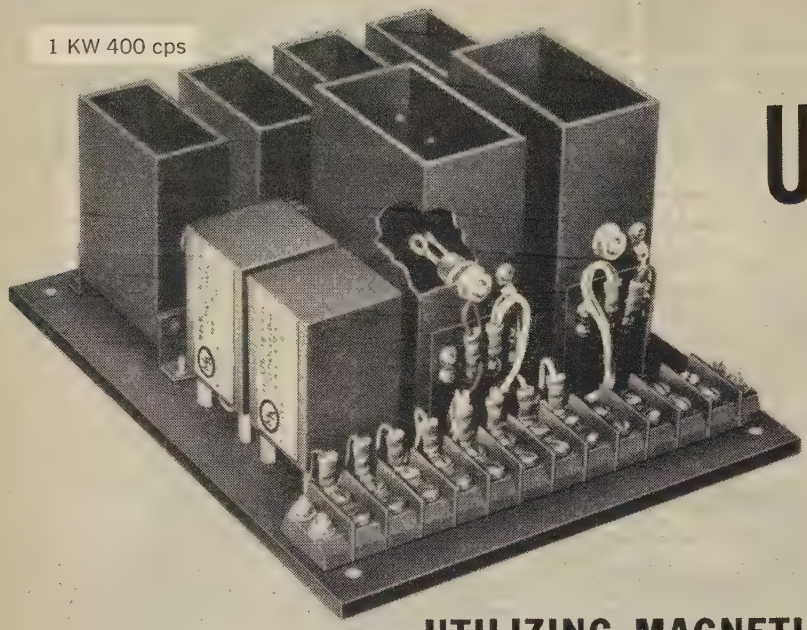
Write for complete data.

KEARFOTT DIVISION

GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

Write in No. 116 on Reader Service Card



NEW! UNIVERSAL POWER CONTROL UNITS

UTILIZING MAGNETIC AMPLIFIERS GATING

SILICON CONTROLLED RECTIFIERS

for military and industrial control of 60/400 cps AC or DC power
200 watts to 3 kilowatts

FIVE CONTROL SYSTEM TYPES AVAILABLE–

*Satisfy 95% of basic power control requirements

CONTROL SYSTEM TYPE I—Provides full wave single ended output. Controls power to AC or DC loads.

CONTROL SYSTEM TYPE II—Provides push-pull two-wire control of AC servo motors.

CONTROL SYSTEM TYPE III—Provides push-pull three-wire control of AC servo motors.

CONTROL SYSTEM TYPE IV—Provides reversible DC output for control of split field series motors.

CONTROL SYSTEM TYPE V—Provides reversible DC output for control of DC shunt motors.

*Any of the five control System Types are readily modified to meet special requirements.

APPLICATIONS FOR: LIGHT DIMMING CONTROL • POSITIONING SERVOS
SPEED CONTROL • TEMPERATURE CONTROL
VOLTAGE/CURRENT REGULATION

Descriptive Brochure, Bulletin S-1075 upon request.

Universal Power Control Units
FOR 60 AND 400 CPS SYSTEMS

120 V 60 CPS SYSTEMS MODEL*	CONTROL TYPE	MAX. POWER OUTPUT	120 V 400 CPS SYSTEMS MODEL*
MCR-650031-Y	I-A	600 VA	MCR-450031-Y
MCR-650031-Y	I-A	500 W	MCR-450031-Y
MCR-610231-Y	I-A	1200 VA	MCR-410231-Y
MCR-610231-Y	I-A	1000 W	MCR-410231-Y
MCR-624241-Y	I-B	2400 VA	MCR-424241-Y
MCR-620231-Y	I-C	2000 W	MCR-420231-Y
MCR-620076-Y	II	200 VA	MCR-420076-Y
MCR-660076-Y	II	600 VA	MCR-460076-Y
MCR-660071-Y	III-A	600 VA	MCR-460071-Y
MCR-612271-Y	III-A	1200 VA	MCR-412271-Y
MCR-624271-Y	III-B	2400 VA	MCR-424271-Y
MCR-650081-Y	IV-A	500 W	MCR-450081-Y
MCR-610281-Y	IV-A	1000 W	MCR-410281-Y
MCR-620281-Y	IV-B	2000 W	MCR-420281-Y
MCR-650086-Y	V-A	500 W	MCR-450086-Y
MCR-610286-Y	V-A	1000 W	MCR-410286-Y
MCR-620286-Y	V-B	2000 W	MCR-420286-Y

*Model numbers having the suffix Y are proportional control units. The same model number with the suffix P is used for ON-OFF switching units, and carry the same ratings as the proportional control models. ON-OFF switching units are available only in control type I.

Inquires invited—Engineering conferences at your or our facilities write, wire or call—

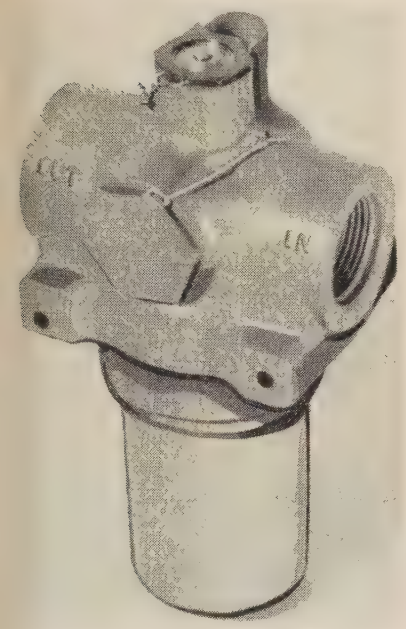
MAGNETIC AMPLIFIERS, INC.

632 TINTON AVENUE
NEW YORK 55, N. Y.
CYPRESS 2-6610

136-140 KANSAS STREET
EL SEGUNDO, CALIFORNIA
OREGON 8-2665

Write in No. 117 on Reader Service Card at start of Product Preview Section

FILTER ASSEMBLIES use ultrafine wire mesh



These filters use ultrafine wire mesh filter elements, rigidified by a special process which bonds all cross wires to each other and are fabricated into high area corrugated construction with positive "maximum particle passed" control. They are for service from 0 to 5000 psi and from —65 deg F to +275 deg F, says **Aircraft Porous Media, Inc., Dept. S/A, 30 Sea Cliff Ave., Glen Cove, N. Y.** Permanent, cleanable, reusable all stainless filter elements are offered for 98 per cent removal ratings of 2, 5 and 10 micron sized particles.

Filter assemblies are offered with no relief valve and with element reinforced to withstand 4500 psi differential pressure.

Write in No. 417 on Reader Service Card

DIELECTRIC MATERIAL for high temperatures

Duroid 5870 is a dielectric material developed primarily for use as a high-temperature circuit base stock, missile antenna dielectric, and as microwave strip insulation, according to **Rogers Corp., Dept. S/A, Rogers, Conn.** The Teflon-coated micro-glass fiber insulating material is available as copper clad sheet, rod, tube, and flat sheet, or as punched or machined parts.

To assure proper functioning at elevated temperatures, a film of Teflon 100X is used as a bonding agent, instead of the adhesive commonly used to bond copper to base stock. Duroid 5870 permits close tolerance control, avoids window effect, and eliminates moisture wicking along the fiber. It also has excellent dimensional stability over a wide temperature range.

Write in No. 418 on Reader Service Card

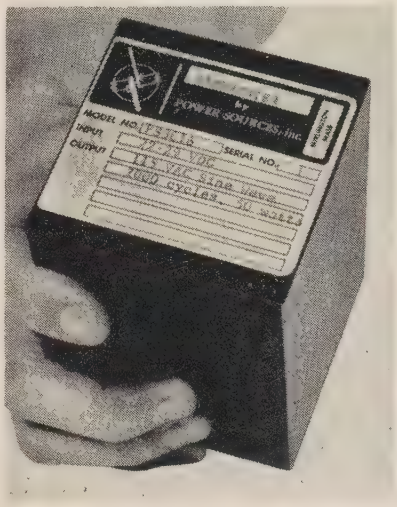
FLOW SENSOR cuts wear and error

This Fluid Bearing Flow Sensor, determines fluid velocity in a constant area passage containing a spinning turbine rotor supported entirely by a fluid film serving as a bearing. Since the rotor floats entirely on the fluid film, wear and error effects from either radial or thrust friction are said to be overcome. This design provides wider rangeability, better reproducibility and unlimited life without sacrificing other characteristics of turbine-type flow sensors, says **Waugh Engineering Co., Dept. S/A, 7842 Burnet Ave., Van Nuys, Calif.**

Ranges of ten to one are obtainable with this instrument with an accuracy of ¼ per cent of the actual flow rate. The unit is claimed to be virtually indestructible and cannot be damaged by continuous overranging up to several times the nominal limit.

Write in No. 270 on Reader Service Card

MISSILE INVERTER eliminates filtering



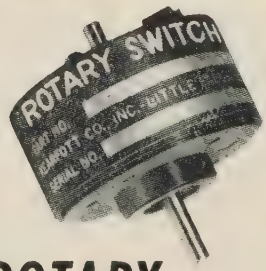
The Model SV2C1200 Sineverter is a general-purpose inverter for use in missiles, aircraft and other applications where the primary ac power frequency is 2000 cps. The device provides clean sine-wave power from any dc source without filtering, says **Power Sources, Inc., Dept. S/A, Burlington, Mass.**

The waveshape is sinusoidal with under five per cent harmonic distortion. Input voltage is 22 to 29 V dc and output, 115 V plus or minus five per cent, 2000 cps plus or minus one per cent, single phase, zero to 50 va. The unit is protected against overload, short or open circuit operation. Operating temperature is —20 to +85 deg C at the mounting base, and a heat sink is required.

Write in No. 271 on Reader Service Card

more on next page

BASIC BUILDING BLOCKS FROM KEARFOTT



ROTARY SWITCH

Kearfott's rotary switching devices for missile and aircraft systems are used to sequence or switch circuitry as a function of time or shaft position. Used in conjunction with sensitive relays or solid state switching techniques, high current loads can be handled. These switches consist primarily of shaft assembly and bearing mounted cylinder divided into conducting and non-conducting segments with continuous track for common input. Multiple conductor "broom" type brushes ride on each cylinder track while number of tracks and segmentation of each is function of the number of circuits and type of "on-off" sequencing required.

TYPICAL CHARACTERISTICS P1280-11A

Number of switching tracks: 2

Angular Segmentation (both referenced to 0° start):
Track 1 — Non-conducting about 0° + 50°
Track 2—Conducting 0° -180°
Non-conducting 180° -0°

Mechanical Accuracy of Segmentation:
±1° (better as required)

Starting and Running Torque:
0.1 oz.-in.

Current Capacity:
50 ma at 28V/Brush (suitable for any sensitive relay or solid state switching circuits)

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY
Write in No. 119 on Reader Service Card

THE S.S.White Industrial Airbrasive® Unit

We don't recommend slicing up the family's fine Limoge China, but this does illustrate the precisely controlled cutting action of the S. S. White Airbrasive Unit. Note how clean the edge is, and how the delicate ceramic decoration is unharmed.

The secret of the Airbrasive is an accurate stream of non-toxic abrasive, gas-propelled through a small, easy-to-use nozzle. The result is a completely *cool* and *shockless* cutting or abrading of even the most fragile hard materials.

Airbrasive has amazing flexibility of operation in the lab or on an automated production line. Use the same tool to frost a large area *or* to make a cut as fine as .008"!...printed circuits...shaping and drilling of germanium and other crystals...deburring fine needles...cleaning off oxide coatings...wire-stripping potentiometers...engraving glass, minerals, ceramics. Jobs that were previously thought impossible are now being done.

Send us samples and specs on your difficult jobs and let us test them for you.

SEND FOR BULLETIN 5705A...complete information.

New dual Model D!

S.S.White®

S. S. WHITE INDUSTRIAL DIVISION
Dept. 21A 10 East 40th Street, New York 16, N. Y.

Write in No. 120 on Reader Service Card at start of Product Preview Section

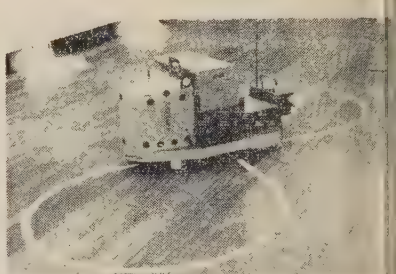
CLOCK COUNTER has large numeral readou

This clock type counter provide 24-hour indications in minutes and hours for elapsed time readout applications. Designated X-950, the counter and other units with slightly different configurations are used in conjunction with equipment requiring periodic service in addition to direct time reading uses, says **Bowmar Instrument Corp., Dept. S/A 8000 Bluffton Rd., Fort Wayne, Ind.**

It is designed for use in temperature ranges from —30 deg C, where input torque is .75 in-oz, to 71 deg C.

Write in No. 272 on Reader Service Card

MECHANICAL ROBOTS for radioactive areas



These robots can lift a half ton of deadweight or repair delicate machinery and are for use by nuclear and research specialists for maintenance and repair work in radioactive areas dangerous to humans. The automatons were developed for use with a new type reactor, according to **Barrett-Cravens Co., Dept. S/A 628 Dundee Rd., Northbrook, Ill.** The largest and most versatile robot weighs 3 tons and is 8 ft tall. A TV camera on its mast clearly views its performance.

This remote-controlled truck can thread a pipe or turn a valve, as well as raise a heavy drum off the floor and hold it 15 ft aloft.

Write in No. 273 on Reader Service Card

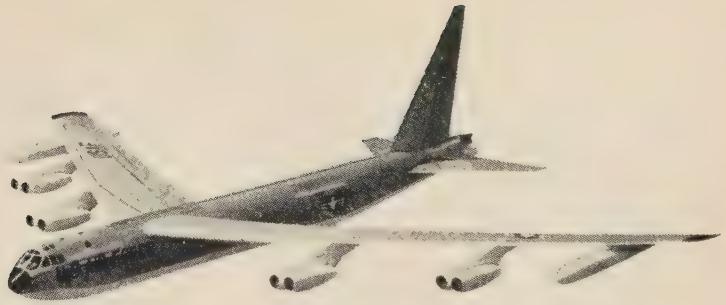
RAIN-TIGHT SWITCH is explosion proo

This switch 12CX3 is rain-tight and explosion proof. It has aluminum die-cast housing and dome cover and is designed for use on fuel handling equipment, rocket and missile launching devices, industrial valve control systems and other hazardous outdoor installations, says **Minneapolis Honeywell, Micro Switch Div., Dept. S/A Freeport, Ill.** Electrical capacity is listed at 20 amps, 125, 250, or 460 vac.

It is said to be capable of undergoing a 100-hour salt fog test without injury to the actuating mechanism of precision switching units.

Write in No. 274 on Reader Service Card

more on page 220



KEARFOTT developed

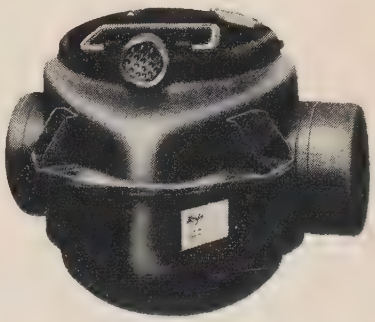
and now produces

precise heading and vertical

reference systems

for the B-52 aircraft.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*



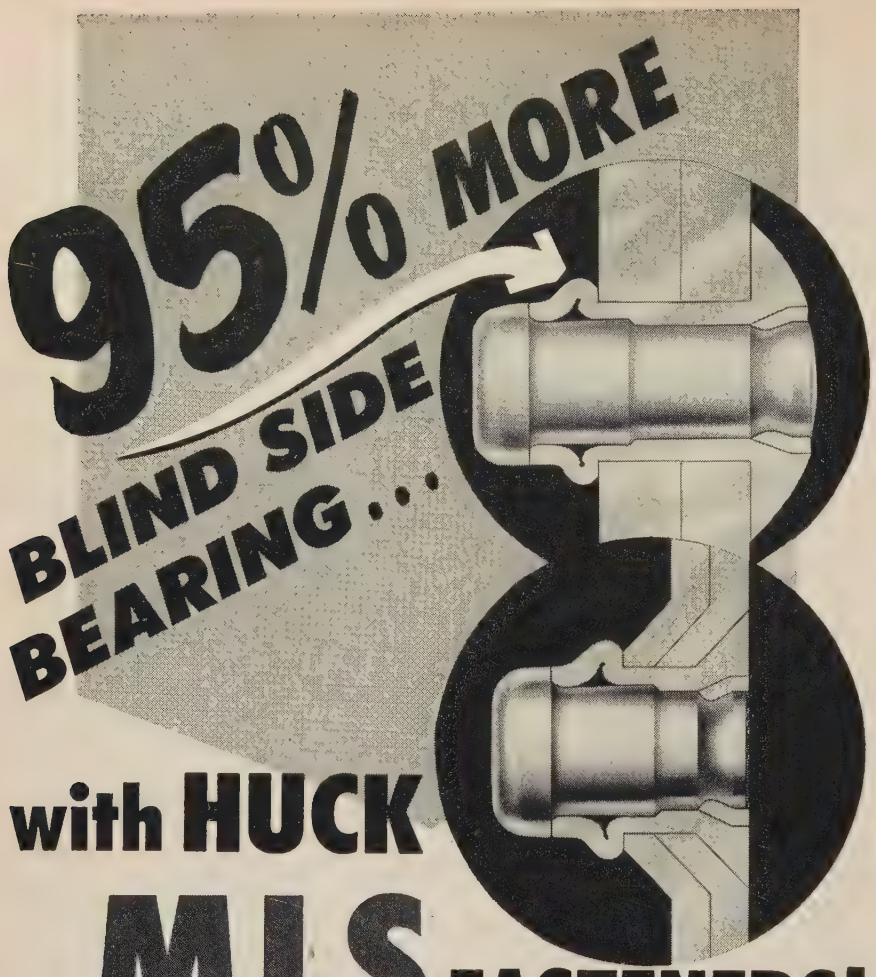
KEARFOTT DIVISION

GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

Other Divisions of General Precision Inc.—GPL—Librascope—Link

Write in No. 121 on Reader Service Card at start of Product Preview Section



with HUCK

MLS FASTENERS!

plus

- Positive mechanical locking.
- Automatic, flush pin break.
- No secondary trimming necessary on ANY pin material.
- No tool stroke adjustment necessary for any grip length — Affords foolproof installation and inspection.
- No problems on thin sheets or double-dimpled applications.
- The only approved lock-spindle blind fastener with over 15 years successful use in the aircraft industry.

The Huck MLS fastener and the easy handling #200 Installation Tool are a time and money saving team. They enable unskilled operators to install up to 30 fasteners per minute with identical tensile preload and uniform perfection. Constant engineering research keeps Huck fastening systems abreast of tomorrow's changing requirements.

HUCK MANUFACTURING COMPANY

2480 Bellevue Ave. • Detroit 7, Mich. • WAlnut 3-4500

Write in No. 122 on Reader Service Card at start of Product Preview Section

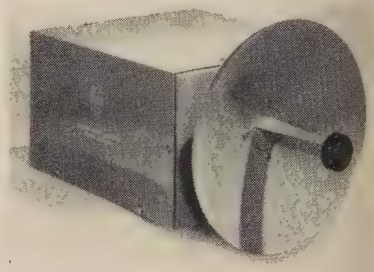
VINYL SLEEVING electric insulation

Development of a vinyl electrical insulation sleeving, called resinite EP-93C, to meet the latest revision (B) of Wright Air Development Center spec MIL-L-7444, has been announced by **Borden Chemical Co., Dept. S/A, 1 Clark St., N. Andover, Mass.** It possesses low-temperature flexibility to —95 deg F., complete resistance to fungus and corrosion, and is self-extinguishing in 1 to 5 seconds. Dielectric strength is rated at 250 to 340 V per mil of wall thickness.

The manufacturer says the product exceeds nearly every specification requirement by substantial margins.

Write in No. 275 on Reader Service Card

POLARIZED ANTENNA is remotely controlled



Model 157 X-band Variable Polarization Antenna features motor-driven remote control of polarization. Stop positions, spaced every 45 deg are selected and locked by a mechanical index, says **Textron Inc., Calif. Technical Industries Div., Dept. S/A, 1423 Old County Road, Belmont, Calif.**

The unit has an 8500-9600 mc frequency range; 50Kw nominal peak power handling capacity; 8½ in parabola; 10 deg beam width; and a 24 db gain. Other frequencies, rating and reflector sizes will be manufactured on request. The mechanism is enclosed in a weather-resistant case measuring 8¾ in by 10 in by 5¾ in.

Write in No. 276 on Reader Service Card

SOLENOID VALVE replaces motor type

A fail-fixed solenoid valve that can replace a motor-driven valve is available for 28 Vdc and 110 Vac operation, for 2, 3, or 4-way operation, air or hydraulic service, for pressures up to 3000 psi and temperatures from —65 deg F to 450 deg F, according to **Dynamic Controls Corp., Dept. S/A, 30 Thomas St., Hartford, Conn.** It weighs 8 oz and requires 5 watts for operation.

Voltage of one polarity will open the valve, and voltage of the reverse polarity will close the valve. It remains in last position if current is interrupted.

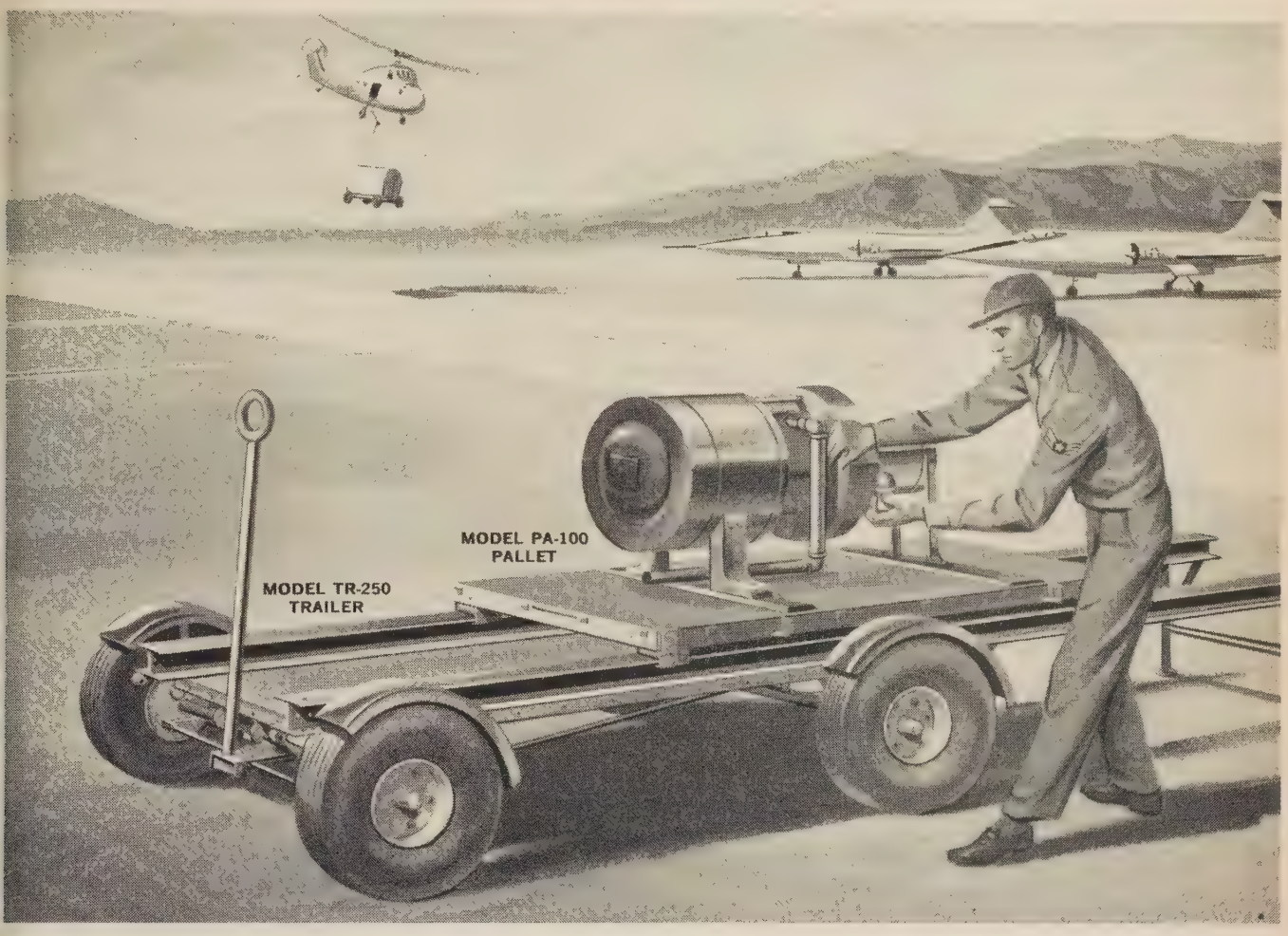
Write in No. 277 on Reader Service Card

more on page 222

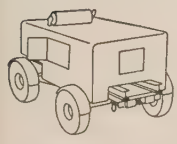
today's most versatile, light weight

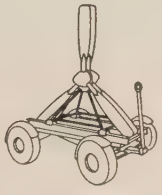
TRAILER-PALLET HANDLING SYSTEM

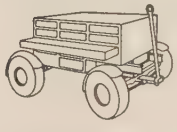
designed for greater mobility, rugged long life, complete supply capability

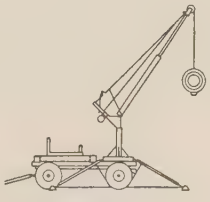


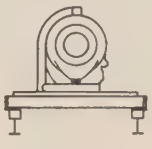
The combination of American Electronics Model TR-250 Universal Roll-Transfer Trailer with the Model PA-100 Basic Pallet provides maximum flexibility in logistical and ground support service. Used together or separately, these versatile units and their accessories are designed for a wide variety of ground support applications.

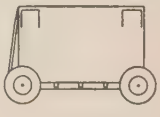

GENERATOR


COMPONENT HANDLING


WORK BENCH


JIB CRANE


ENGINE REPAIRS


CONTAINER

Please write for the new brochure giving complete details on AEI's Universal Trailer-Pallet System.

Engineering opportunities are available

AMERICAN ELECTRONICS, INC.

GROUND SUPPORT DIVISION

2112 NORTH CHICO AVENUE, EL MONTE, CALIFORNIA

Write in No. 123 on Reader Service Card at start of Product Preview Section

SOUTHWEST
"Monoball"®
SELF-ALIGNING
BEARINGS

ROD END
TYPES

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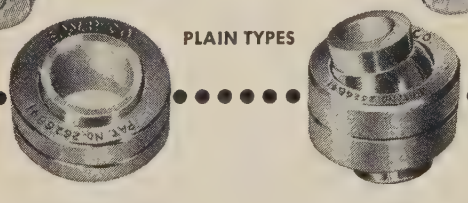
PLAIN TYPES



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 60.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Write in No. 124 on Reader Service Card

AIR COMPRESSOR for high pressure

This lightweight air compressor is designed for applications requiring pressures up to 3,000 lb per sq in. Its total weight is 19¾ lb and the maximum dimensions are 12x12¼x8 in. Model 326 provides a capacity of 3 cu. ft. per min of free air; model 380, 4 cu. ft per min, says **Cornelius Co., Aero Div., Dept. S/A, 550 39th Ave., N. E., Minneapolis, Minn.** Typical applications include ground support of aircraft and missiles, testing pneumatic components, filling air breathing apparatus and flame thrower tanks, and intermittent operation of small pneumatic tools.

Both models are supplied with matched gasoline, electric or hydraulic power sources, or with standard mounting pads. Each model has a pneumatic safety, control and delivery system.

Write in No. 278 on Reader Service Card

PRESSURE SWITCH has one moving part

This absolute pressure switch to open or close an electrical circuit automatically, called the Pressurmite, model 655, will actuate control and warning systems and is described as having many applications in the aircraft, missile and industrial control fields. It is 2 in and weighs 2¼ ozs, according to **Bendix Aviation Corp., Dept. S/A, So. Bend 20, Ind.** It can be used to perform electrical control function at required altitudes or pressure, to detect loss of pressure in hermetically sealed electronic equipment, or in aircraft cabin pressure and oxygen demand systems.

The unit has one moving part, a pressure-sensing diaphragm that is insensitive to temperature changes over a wide span.

Write in No. 279 on Reader Service Card

PORTABLE TEST SET for liquid oxygen

A portable, self-contained test set that permits complete checkout of aircraft liquid oxygen systems, without removing system components from the plane, has been announced by **Consolidated Airborne Systems, Inc., Dept. S/A, 72 E. 2nd St., Minneola, N. Y.** Designated model TL-2, it can be used for bench testing LOX system components during maintenance or for new unit inspection.

The manufacturer says the unit will accommodate all standard airborne LOX quantity systems and provides all necessary functions for measuring capacitance of converter probes, testing indicator-amplifier operation, measuring electrical leakage resistance, determining evaporation loss and monitoring converter filling.

Write in No. 280 on Reader Service Card

THERMOCOUPLES for rocket engine

These thermocouples for immersion, heat transfer and surface temperature measurements are for missile and rocket engine application in temperature ranges of —350 deg F to +2000 deg F. Materials are made from various types of premium grade wire meeting NBS 14 RP 2415 curves and calibrated at two points, says **Astra Technical Instrument Corp., Dept. S/A, 1132 Mission St., S. Pasadena, Calif.** Characteristics are:

Heat transfer type: location of thermocouple junction controlled within ±.110 in of a fixed distance from the surface. Surface Temperature: plug, screw and flat mounted types with junction at surface. Immersion: average response time better than 250 milliseconds; hydrostatically tested to 5000 psi.

Write in No. 281 on Reader Service Card

more on page 224

How satellites can give us low cost emergency telephone service

Launched by the Douglas-built *Thor* IRBM, satellites like this would relay telephone messages anywhere in the world without costly cables or towers.

Beyond their immediate military necessity, our present rocket and missile programs promise many vital peacetime benefits to us all...

Well past the drawing board stage are plans to use satellites as a low-cost emergency stand-by system to relay telephone calls around the world.

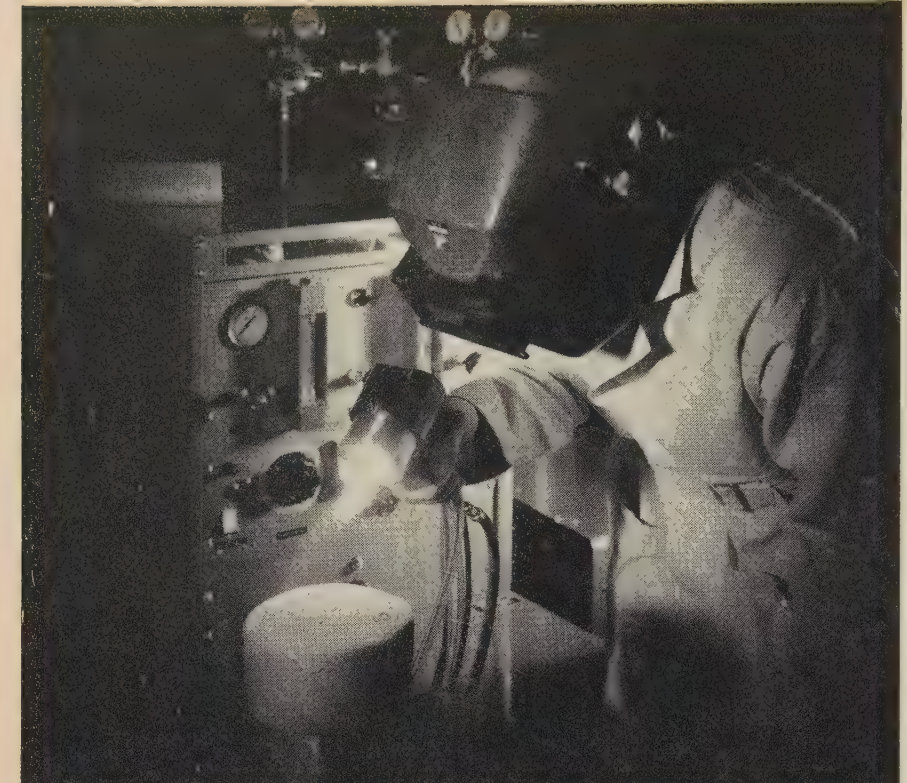
Your call would be beamed to a satellite, then bounced back to a receiving station on Earth. Cost is estimated at a fraction of what must be spent to install and maintain cables or radio relay towers.

While satellite telephone service is still in the future, *Thor*—the rocket that can put it into being—is thoroughly proved. Built by Douglas, maker of the DC-8 jetliners, *Thor* has been successful in more than 90% of its shots. It is key booster in the "Discoverer" firings and launched the first nose cone recovered at ICBM range.

Thor is another product of the imagination and experience gained by Douglas in 20 years of missile development.

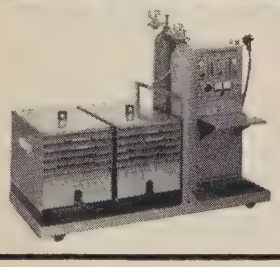
DOUGLAS

MISSILE AND SPACE SYSTEMS
MILITARY AIRCRAFT • DC-8 JETLINERS
TRANSPORT AIRCRAFT • AIRCOMB
GROUND SUPPORT EQUIPMENT



NEW, PLASMATRON HAND SPRAY GUN

TEMPERATURES TO 30,000°F WITHOUT OXIDATION!



Basic Plasmatron Spray System (left) consists of control console, power supply and hand-held spray gun.

Compact Plasmatron Spray Gun weighs less than 4 lbs., is extremely flexible.

The compact, lightweight, hand-held Plasmatron® Spray Gun is an inexpensive, practical method of depositing dense coatings of high melting point materials such as tungsten, carbides, borides, nitrides and refractory oxides for use as erosion, corrosion, thermal and electrical barriers.

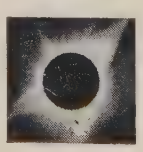
Producing an ionized jet of gas from an electrical arc, the Plasmatron Spray Gun achieves plasma temperatures three to five times that of an oxyacetylene flame. And the inert jet offers a completely uncontaminated spraying environment which does not oxidize either the substrate or the sprayed material.

Significant advantages of the Plasmatron Spray Gun are its lightweight, (only 3.8 lbs.) small size and low cost.

New Plasmatron applications are continually being discovered in the missile, spacecraft, chemical, nuclear, mining and petroleum industries. Techniques have been successfully developed which allow spray coating of various substrates of metals, ceramics, plastics and glass.

For a detailed, illustrated brochure on the Plasmatron Spray Gun, phone KImberly 5-7171, or write:

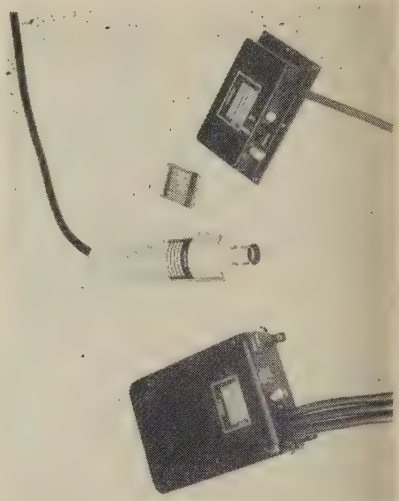
plasmadyne
A SUBSIDIARY OF GIANNINI SCIENTIFIC CORPORATION
3839 S. Main Street • Santa Ana, California



Other Plasmadyne products and services include hyperthermal tunnel material testing, larger Plasmatron Systems and hyperthermal wind tunnel installations.

Write in No. 125 on Reader Service Card at start of Product Preview Section

VIDEO TELEMETRY SYSTEM for missiles



Model 701, a small compact Video Telemetering System is designed specifically to meet the stringent requirements of missile applications. The unit is capable of operation under extreme environmental conditions and is packaged for use under conditions requiring limited space, weight and power, says **Lockheed Electronics & Avionics Div., Dept. S/A, P. O. Box 22124, Los Angeles 22, Calif.**

The Model 701 includes such features as transistorized circuitry, 525 line, 30-frame fully-interlaced picture, crystal controlled EIA synch, and high sensitivity. The entire system occupies only 118.8 cubic inches and weighs but 5.9 lb. It will withstand shocks of 40 G for 11 milliseconds in three planes and acceleration of 45 G.

Write in No. 282 on Reader Service Card

COMPACT VALVES have large capacity

The FX line of Quick-Dump piloted valves for automated or manual control of air, gas, vacuum, and liquid flow emphasizes compactness with large capacity, says **Humphrey Products, Dept. S/A, 202-N N. Park St., Kalamazoo, Mich.** The valves, designed for pressures to 125 psi, contain diaphragms that will cycle from full open to dead seal shut-off at up to 30,000 per hr.

Opening, closing and exhausting functions are powered by line pressure and require only a triggering impulse from pilot. The pilot medium, a gas or liquid, is separated from the medium being valved. The valves have no packings, pistons, or metal-to-metal wearing contacts. The units are available in 2-3 way sizes of ⅛, ¼, and ½ in., and in a 4-way, 5-port ¼-in. model for double-acting cylinder control. Temperature range for the valve is −65 to +225 deg F.

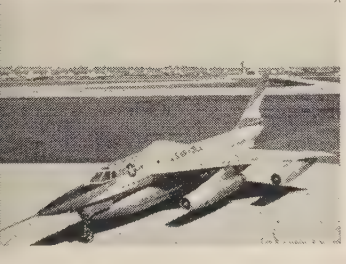
Write in No. 283 on Reader Service Card

more on page 226

nstallation of flexible fire seal in wing of B-58. Fabric coated with VITON synthetic rubber will resist up to 500° F. Other uses for this new heat and chemical resistant rubber: O-rings, gaskets, hose and tubing, diaphragms and a host of molded parts for engines, instruments, transmissions.

HOW VITON® BEATS THE HEAT AT MACH 2

Asbestos coated with new fluorocarbon rubber takes 500° F. temperatures in fire seals for B-58



Convair pioneered the use of elastomer-coated asbestos fire seals for equipment access tunnels in the wings of the B-36. But the new B-58, traveling at Mach 2 speeds, presented a more difficult problem—higher operating temperatures.

Convair had to find a fire seal material that would tay flexible at 500° F. temperatures. They found it—Du Pont's new VITON synthetic rubber. Asbestos coated vith this elastomer not only stood up to Mach 2 heat equirements, but gave the needed resistance to ozone, et fuels, fumes, corona, pressure and vibration as well.

VITON meets government specification MIL R25897 for a high-temperature, fluid-resistant synthetic rubber for aeronautical application. This VITON-coated fabric actually performs better than aluminum would; it is equivalent to *stainless steel* in retarding the transfer of heat, according to Civil Aeronautics Administration specifications.

Where can *you* use VITON's remarkable combination of properties? It stays elastic for long periods at temperatures as high as 600° F. . . . resists chemicals, solvents, fuels, lubricants . . . even at elevated temperatures. It's worth investigating; write for complete technical information to: E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAR-3, Wilmington 98, Delaware.

DU PONT
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SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

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the true gauge of quality

MicroRold®

STAINLESS STEEL

SHEET & STRIP

FIFTEEN YEARS AGO, we were the first stainless steel sheet producer to recognize the superiority of the Sendzimir Cold Reduction Process over conventional rolling equipment for exceptionally close tolerances.

Our equipment is such that tolerances can be held to as low as 3% (plus or minus), as compared to the A.I.S.I. maximum allowable variation of 10%. This "Thinness Control" means the ability to control decimal thickness with micro-accuracy, giving you more stainless area per ton or the equivalent area with less weight. It is this controlled accuracy and uniformity that directly relates to fabricating economies and satisfaction in the ultimate end use.

MicroRold Stainless Steel Sheet is available in widths up to 36" in gauges from .005 to .109, and in widths up to 48" from .010 to .109 in all commercial grades, finishes and tempers. MicroRold Strip can be supplied in widths up to 23 15/16" in gauges from .010 to .109, and VERI-THIN Strip as thin as .0015 to .009 in all commercial strip finishes.

Distributed by steel warehouses throughout the world!

Send for your copy of "MicroRold Stainless Steel Handbook"

WASHINGTON STEEL CORPORATION

WOODLAND AVENUE • WASHINGTON, PENNSYLVANIA

Write in No. 127 on Reader Service Card at start of Product Preview Section

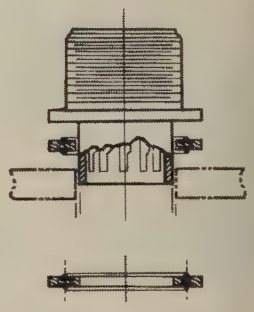
SPRAG CLUTCHES uses chromallizing

This over-running sprag type clutch uses a chromallizing process and the sprags are made from high carbon alloy steel. Chromallizing results in a high temperature alloying of chromium and the carbon steel, says **Formsprag Co., Dept. S/A, 23601 Hoover Rd., Warren, Mich.** Extreme resistance to abrasion and corrosion is claimed.

It is said there is no chipping, cracking or flaking of surface alloy.

Write in No. 284 on Reader Service Card

RE-USEABLE SEAL eliminates gland



This re-useable seal for most styles of AN 3102 type electrical connectors uses the principle of controlled confinement of a seal in a metal retainer. It is one-piece, rigid construction. The need for grooving to accommodate a seal gland is eliminated, says **Parker Seal Co., Dept. S/A, 10567 Jefferson Blvd., Culver City, Calif.**

The seal provides metal-to-metal contact of faying surfaces. It can be re-used many times and cleaning or re-working of the flange, when replacing, is avoided.

Write in No. 285 on Reader Service Card

FREQUENCY DETECTOR has expanded scale

The expanded-scale Magmeter, a frequency detector, delivers an output current directly proportional to input frequency at an accuracy of 0.1 per cent. These solid-state frequency detectors cover a 10 per cent bandwidth at any center frequency in the audio range, says **Airpax Electronics Inc., Dept. S/A, Seminole Div., Fort Lauderdale, Fla.**

The unit is insensitive to changes in input amplitude and waveshape and will fit a standard octal socket. Weight is less than 4 oz, height is 2 in. Operation is from −55 deg C to +72 deg C.

Write in No. 286 on Reader Service Card

more on page 230

Photo courtesy Douglas Aircraft Corp.

for optical clarity

DC-8's* use L·O·F Aviation Glass

You'll find this glass in Lockheed Electras, Convair 880's, Canadaires, Boeing 707's, and other great planes flying international airways.

Why? Because L·O·F is one of America's most technically advanced producers of flat glass. And every piece made for aviation use is "grid photo-tested" for optical clarity.

Glass has amazing properties for many kinds of aviation applications. To take full advantage of these properties, call in an L·O·F technical adviser right from the start. He knows the science of glass and its uses, and can save you time and money. Aviation Division, Dept. 9930, 811 Madison Ave., Toledo 3, Ohio.

*Made for United and Delta Airlines

LIBBEY·OWENS·FORD LOF GLASS *a Great Name in Glass* Toledo 3, Ohio

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Westinghouse ATLAS erector contro

A single button is pressed . . . prefiring checkout starts and the smooth, programmed rise to firing position begins for the mighty Convair ATLAS.*

The Westinghouse React-O-Verse control system automatically raises the missile to its vertical firing position, checks to make sure that the missile is firmly seated on the launching pad, retracts and rotates the nose clamp and moves the erector boom out of the way—all without flexing or straining the bird at any point in the arc. A very complex and demanding job for electromechanical control.

This precision control, which compensates au matically for varying loads or wind pressures fr any direction, is achieved with an exclusive We inghouse system combining maximum reliabil with watch-like accuracy. Static controllers, sat able reactors and Cypak® (miniaturized magam units program, check position and release, or, at a malfunction, return the missile to its horizontal po tion. No moving parts are present to corrode, w

ystem assures handling reliability

, require maintenance or fail at a vital instant. Whatever your requirements for ground support uipment drive systems—erectors, launchers, lters, loaders—or shockproof equipment for dened sites, take advantage of the Westinghouse ineering knowledge, range of products and unit ponsibility for any type of electromechanical sys-. Contact your Westinghouse sales engineer or te: Westinghouse Electric Corporation, 3 Gate- Center, P. O. Box 868, Pittsburgh 30, Pa.

**The new ATLAS erector system is supplied by Goodyear Aircraft Corporation, Arizona Division, Litchfield Park, Arizona, under contract to Convair Astronautics Division, San Diego, California, prime contractor to USAF for ATLAS.*

J-92039

YOU CAN BE SURE...IF IT'S

Westinghouse

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FACTORY FRESH CERTIFIED PRECISION

APPCO PRECISION STOCK GEARS

32 TO 120 PITCH . . . A.G.M.A. PRECISION #1, 2 & 3
SEALED IN PLASTIC . . . DIRT AND SCRATCH-FREE

Made to exacting specifications. Held to tolerances which are Certified to precision-fit standard instrument bearings, shafting, etc. Then sealed in plastic free of dust, dirt or corrosion on a shipping tray which identifies each individual gear. The unsurpassed accuracy of APPCO Precision Gears arrive at your plant "factory-fresh" ready to use on the most critical assemblies.

APPCO Certified Precision Stock Gears are available in 32, 48, 64, 72, 96, and 120 diametral pitches of 14½° and 20° pressure angles. Spur gears, pin or clamp hub type . . . flat or hubless . . . anti-backlash. Each is Certified to meet or surpass A.G.M.A. specifications. For complete technical data and catalog write to . . .

ATLAS PRECISION PRODUCTS COMPANY
Div. Prudential Industries, Inc.
Castor & Kensington Avenues
Philadelphia, Pa.

APPCO
PRUDENTIAL INDUSTRIES
APPCO ATLAS MRC
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Write in No. 130 on Reader Service Card at start of Product Preview Section

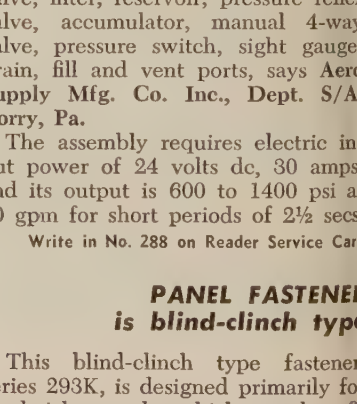
TRANSFORMER mounts in small space

Designated "Thin-Tran," this transformer is fully encapsulated and hermetically sealed and will meet military specifications. Standard units operate at 115 V, 400 cps, and are available with secondary voltages from 5to 2000 V. Life expectancy is 10,000 hrs, says **Arnold Magnetics Corp., Dept. S/A, 4613 W. Jefferson Blvd., Los Angeles, Calif.**

The regulation of the unit is 5 per cent maximum, no load to full load. Ambient temperature is from —55 deg C to +100 deg C. The unit weighs 15 oz and measures 1 3/16 x 2¼ x 3 in.

Write in No. 287 on Reader Service Card

HYDRAULIC PACKAGE weighs 27 pounds



This 27 lb hydraulic power package, No. 64-2415-000, is primarily for short time, high peak power supply application. It is designed to operate large volume piston actuators. The package has motor, pump, check valve, filter, reservoir, pressure relief valve, accumulator, manual 4-way valve, pressure switch, sight gauge, drain, fill and vent ports, says **Aero Supply Mfg. Co. Inc., Dept. S/A, Corry, Pa.**

The assembly requires electric input power of 24 volts dc, 30 amps, and its output is 600 to 1400 psi at 10 gpm for short periods of 2½ secs.

Write in No. 288 on Reader Service Card

PANEL FASTENER is blind-clinch type

This blind-clinch type fastener, series 293K, is designed primarily for sandwich panels which employ fibrous type skins or cover sheets such as plywood, where the tensile strength of the cover material is low. Applications are in aircraft, missiles, electronics, commercial and residential architecture and building, says the **Delron Co., Inc., Dept. S/A, 5224 Southern Ave., So. Gate, Calif.** It is one preassembled part.

The knurled portion bites the inside surface of the drilled hole in the cover sheet and a pneumatic gun spreads the prongs.

Write in No. 289 on Reader Service Card

more on page 232

BENDIX FUEL NOZZLES MAKE COLD STARTING SURE

When pilots "scramble", there's no time to fool with cold start problems. That's why Bendix Fuel Nozzles are being specified on more and more jet engines—missiles and helicopters, too. Besides overcoming the cold start problem on the ground, these nozzles overcome in-flight starting difficulties after flameouts occur.

Bendix Fuel Nozzles are mass-produced out of long experience to give greater economy and dependable performance through advanced design and manufacturing processes. Today, they are used on engines powering aircraft all the way from the T-37A to the B-47.

Write for details on how Bendix Fuel Nozzles can solve your specific problem.

Bendix-Elmira

Eclipse Machine Division
Elmira, N. Y.

Bendix AVIATION CORPORATION

Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Write in No. 131 on Reader Service Card at start of Product Preview Section

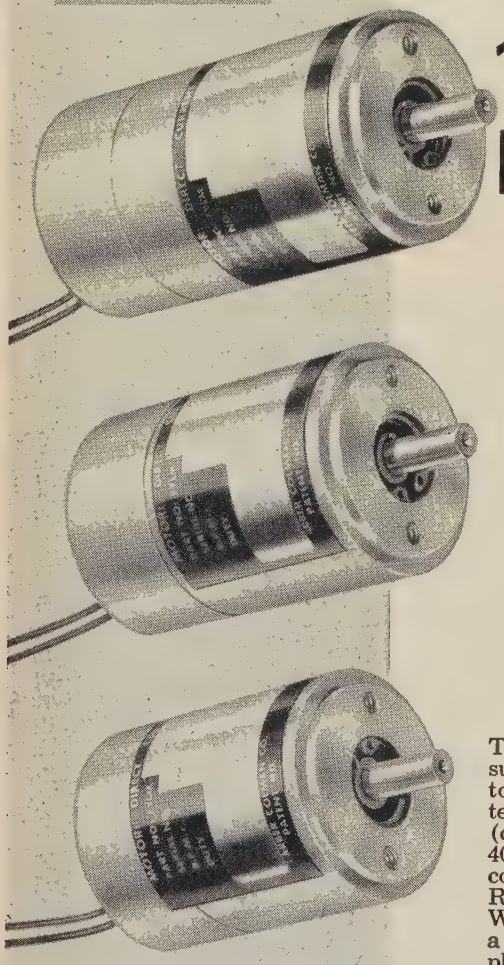
THE MARK OF QUALITY

BARBER COLMAN

d-c small motors

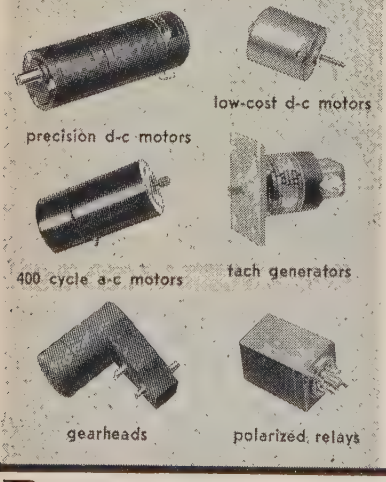
TYPE FYLM

1¼" DIAMETER PERMANENT MAGNET MOTORS



- Three standard frame lengths
- Constant brush pressure over entire motor life
- Large, rugged bearings
- Very low ripple — 14-bar commutator and 14-coil armature
- Standard or special mountings for interchangeability with other motors
- Radio noise filters, gearheads and other special features available

This popular sized motor can be supplied in voltages from 6V d-c to 115V d-c. Normal ambient temperature range −65° to 200°F (can be designed for −100°F or 400°F). Rated output, 10 mhp continuous to 35 mhp intermittent. Rated torque, .05 lb-in. to .16 lb-in. Weight, .26 lb to .43 lb. If you have a new or replacement motor application, contact Barber-Colman.



THE WIDE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS includes: *D-C Motors* for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . permanent magnet and split series types . . . various mountings and speeds . . . also available with gearheads or blowers. *400 Cycle A-C Motors* for aircraft and missile applications. *Tach Generators* for accurate speed indication and servo rate control applications. *Low-cost battery-operated motors. Ultra-Sensitive Polarized Relays* operating on input powers as low as 40 microwatts.

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman electrical components. Includes detailed specifications on a-c and d-c motors, tach generators, blowers, gearheads, relays.

BARBER-COLMAN COMPANY

Dept. C, 1823 Rock Street, Rockford, Illinois

Electrical Components • Small Motors • Automatic Controls • Industrial Instruments
Aircraft Controls • Air Distribution Products • Overdoors and Operators
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Write in No. 132 on Reader Service Card at start of Product Preview Section

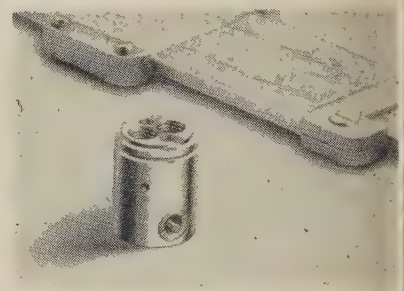
MOTOR GENERATOR weighs 1.3 ounces

This size 6 damping motor generator weighs 1.3 oz and will deliver a stall torque of 0.11 oz-in min. Acceleration from stall is 23,600 rad/-sec/sec, and moment of inertia is 0.33 g-cm$_2$, says **Daystrom Transicoil, Dept. S/A, Worcester, Montgomery Co., Pa.** Generator requires an input of 1.25 W, 26 V at 400 cps.

The maximum null is 12 mv, and the minimum signal to noise ratio does not exceed 8.

Write in No. 290 on Reader Service Card

INERTIA SWITCH has single moving part



This acceleration switch, for applications involving critical control or limits on acceleration changes in two directions, is for use in missiles and aircraft. The series 5 I-S switch is responsive to axial acceleration, uni- and bi-directionally, from 5 g to 50 g. Its actuating time is 20 millisecs, with accuracy within 5 per cent, says **Inertia Switch, Inc., Dept. S/A, 311 W. 43rd St., New York 36, N.Y.** It has one moving part, a precision ground ball held by a uniform magnetic field.

It is factory pre-set, with nominal setting specified by the user. Its service life is 100,000 cycles. Meets MIL-E-5272-A.

Write in No. 291 on Reader Service Card

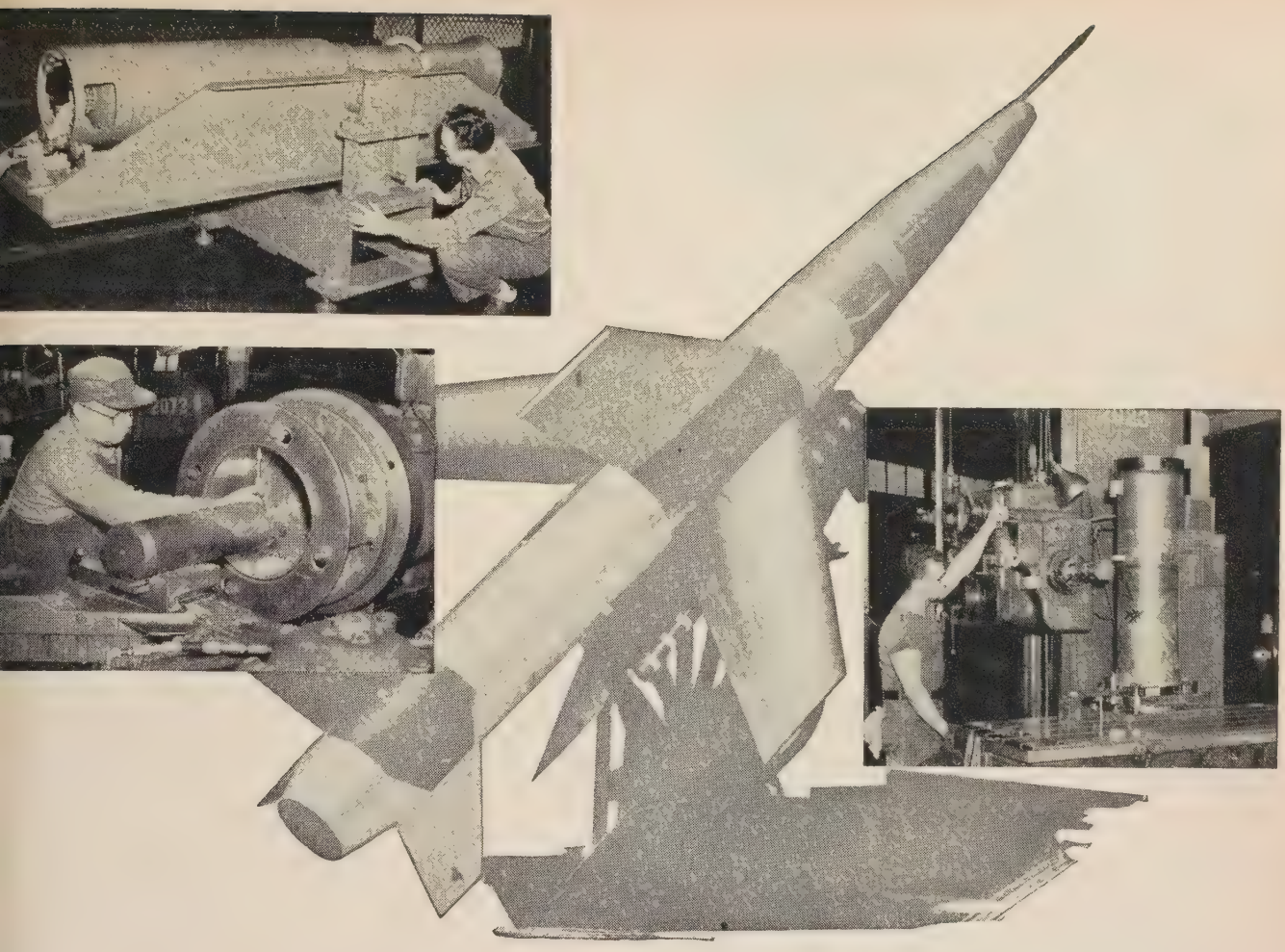
SHAFT COUPLINGS in Oldham and disc types

These three types of precision-made shaft couplings include a 1 in diameter Oldham coupling, a ¾ in Oldham coupling and a disc-type coupling. The Oldham couplings, consisting of two hubs and a floating element, are available with either clamp or pin-type hubs to accommodate any combination of ⅛, 3/16 and ¼ in shafts, says **Beckman Instruments, Helipot Div., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** They tolerate a maximum of 1/64 in lateral shaft misalignment and little or no angular misalignment.

The disc-type coupling is suitable for applications where no backlash can be tolerated.

Write in No. 292 on Reader Service Card

more on page 234



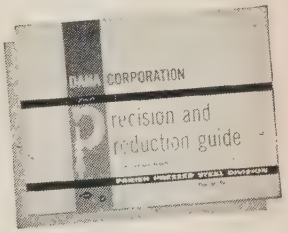
Missiles destined to be on target are built with PARISH precision

The U.S. Army's missile . . . La Crosse . . . is designed to kill in a single shot. That's why Martin engineers insist on the most rigorous specifications and why Parish was selected as subcontractor for the engine metal parts assembly.

Precision . . . for absolutely controlled flight . . . is built into every part of the Parish assembly. Balance is critical and the weight of the entire assembly cannot vary more than ¼ of 1% of design weight. Add another factor . . . complete interchangeability . . . and you'll see why Parish is one of the select few subcontractors regularly mass producing for the missile industry.

Parish has the experienced men and the precision tools for still another missile contract. Why not insure performance by calling Parish today?

WRITE TODAY . . .
For free booklet describing Parish facilities and equipment that can help cut costs for you.



DANA PRODUCTS: Transmissions • Universal ...ts • Propeller Shafts • Axles • Torque Con...ers • Gear Boxes • Power Take-offs • Power ...e-off Joints • Rail Car Drives • Railway Gen...tor Drives • Stampings • Spicer and Auburn ...ches • Parish Frames • Spicer Frames • Forgings

PARISH PRESSED STEEL

DANA Division of Dana Corporation / Reading, Penna.

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Environmental Chambers

AND LOW TEMPERATURE FREEZERS

FOR CONTROLLED ATMOSPHERIC CONDITIONS

Temperature • Altitude • Humidity

Free!

28-Page Brochure on Environmental Chambers

It's one of the most helpful brochures ever published for users of environmental chambers and low temperature freezers.

WRITE FOR YOUR COPY TODAY!

A FEW APPLICATIONS

Aging of Steel
Aluminum Storage
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Nuclear Radiation Testing
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Shrink-fitting of Parts
Rivet Storage
Stabilization of Steels
Simulated Atmospheric Conditions
Thermal Shock Tests
Tool Steel Treatment

RANGES

Temperature: —225° F. to + 1000° F. (Any temperature desired in this range)
Altitude: 0 to 500,000 ft.
Humidity: 20% to 95%
Capacity: Any size for any application

WEBBER MANUFACTURING CO., INC.

P. O. Box 217C * Indianapolis 6, Ind. * Phone: MElrose 2-1378

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A seal is only as good as its performance

HADBAR O-Rings have durability . . .

Where it counts!

Almost any O-Ring will function under ordinary conditions . . . but, in most tough problems . . . temperature extremes, corrosion, high pressure in conveying chemicals, searching liquids, fuel oils, steam or hydraulic applications, specify the HADBAR 1000-80 O-Ring.

Molded of a high modulus, fuel resistant fluorosilicone rubber compound the HADBAR O-Ring contains no plasticizers, retains low temperature flexibility even after long periods of immersion in fuels, and is not affected by ozone and weather.

HADBAR also custom molds and extrudes this rugged proprietary compound into seals, clamps, diaphragms and other products for a wide variety of applications in many critical areas of advanced design fuel, lubricant and hydraulic systems. It may be the answer to your problem . . . get in touch with us . . . we have the skills and facilities to help you.

HADBAR INC.

9530 GIDLEY ST., ROSEMEAD, CALIFORNIA, CUmberland 3-4121

Write in No. 135 on Reader Service Card

CIRCUIT BREAKER takes shocks of 100 g

This miniature electro-magnetic, inverse time delay circuit breaker features an ultimate trip level of 125 per cent of rated current which is independent of ambient or operating temperature and resists shocks of 100 G. It is adaptable to a wide range of ratings, including various trip levels and time delays, says **Airpax Electronics Inc., Dept. S/A, Cambridge, Md.** The short delay for use in protecting electronic equipment; the long, for protection against nuisance trips caused by line transients.

Units are available for interrupting 50 dc volts at currents from 0.05 to 10 amp and for interrupting 120 rms volts, 60 to 400 cps at currents from 1.0 to 10 amp.

Write in No. 293 on Reader Service Card

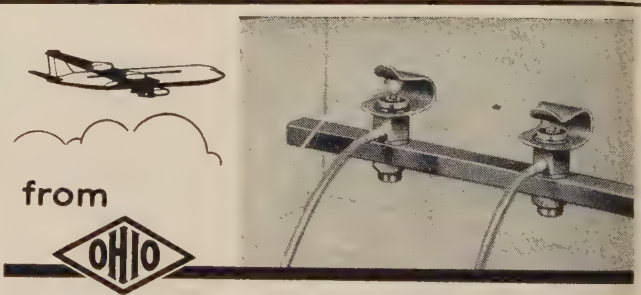
POTENTIOMETER uses linear motion

This high temperature linear motion potentiometer, model 113, is designed to operate at temperatures from —65 deg F to +500 deg F. It will give precision electrical indication of mechanical position when used with hydraulic actuators, pneumatic valves and linage components, says **Bourns, Inc., Dept. S/A, P. O. Box 2112, Riverside, Calif.** The instrument operates with a high level ac or dc signal, requiring no amplification for use in recording, control and telemetering circuits.

Its size is ½x⅝x2½ in. Travel range is 0-1.31 in. Power rating, 4.0 watts at 40 deg C. Available resistances: 1000, 2000, 5000, 10,000, and 20,000 ohms. Resolution, from .0013 to .0035 in.

Write in No. 294 on Reader Service Card

more on page 236



from OHIO

a new passenger jet aircraft

EMERGENCY DECOMPRESSION FLOW CONTROL VALVE

A compact, lightweight valve for installation in the emergency oxygen compartment. Valve stands 1⅛" above the manifold and is ¾" in diameter. Total weight is 0.8 oz. Can be individually or manifold mounted.

Valve is actuated when mask is removed from compartment by the passenger. It can be quickly and easily reset. Flow characteristics conform with altitude requirements.

For complete data and free engineering aid from specialists in aviation oxygen systems, please write to: Aviation Department.

OHIO Ohio Chemical

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.
Madison 10, Wisconsin
(A Division of Air Reduction Company, Inc.) AIRCO

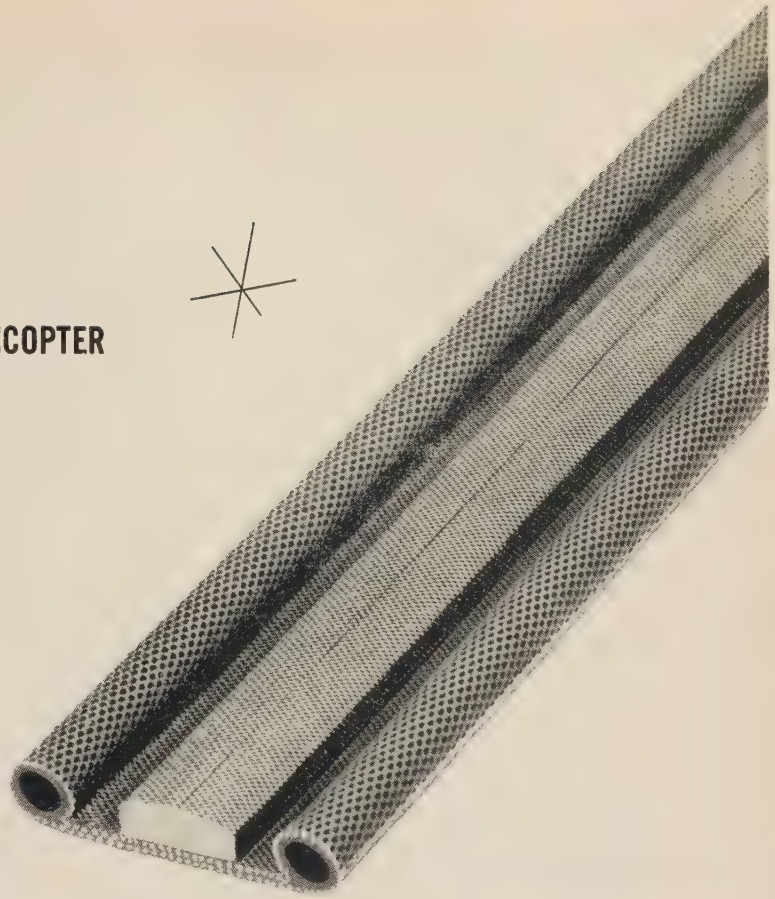
Write in No. 136 on Reader Service Card

CHR SEAL SOLVES PROBLEM ABOARD NAVY'S FIRST AMPHIBIOUS HELICOPTER

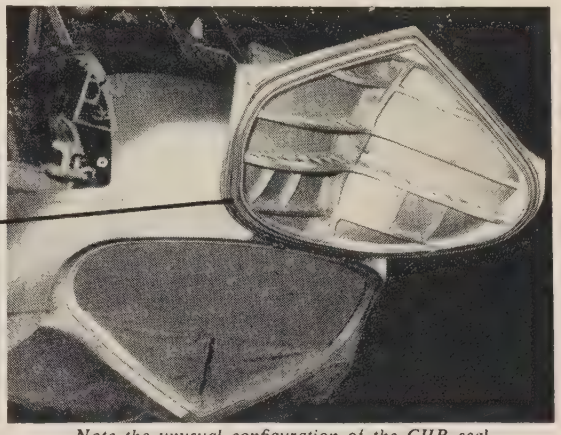
Water pressure during take-offs and landings of the new Sikorsky HSS-2 necessitates positive sealing of the lightweight service door to the electronic compartment.

Water-tight sealing over the door's complex contour is achieved with the unique CHR seal shown. Specially designed to withstand the varied water pressures encountered in service, this tough seal is made of silicone rubber with a dacron reinforced fabric cover. A special CHR silicone sponge rubber compound runs through the center rise of the seal insuring a water-tight seal on the striker surface. The two bulbs on either side of the center rise, act as secondary seals and take up any gap between metal surfaces of door and bow.

Though lightweight, this effective seal can withstand the extreme weathering, wear and abrasive conditions encountered during flight operations of this remarkable aircraft.



SIKORSKY'S HSS-2 — Navy's first, all-weather, twin-turbine powered amphibious helicopter, designed for anti-submarine service.



Note the unusual configuration of the CHR seal on the lightweight electronic compartment door. This was required by its complex contour.

CHR specializes in the production of all types of silicone rubber air frame and engine seals for −100°F to 600°F temperature applications. For design or production assistance with your sealing problems, write or phone CHR today. Our field representatives are available for direct contact.

CHR

COHRlastic Aircraft Products: SEALS • COATED FABRICS • DUCTS

CONNECTICUT HARD RUBBER COMPANY

Main Plant • New Haven 9, Connecticut

CHR Sales Offices • Atlanta • Los Angeles • St. Louis • Seattle

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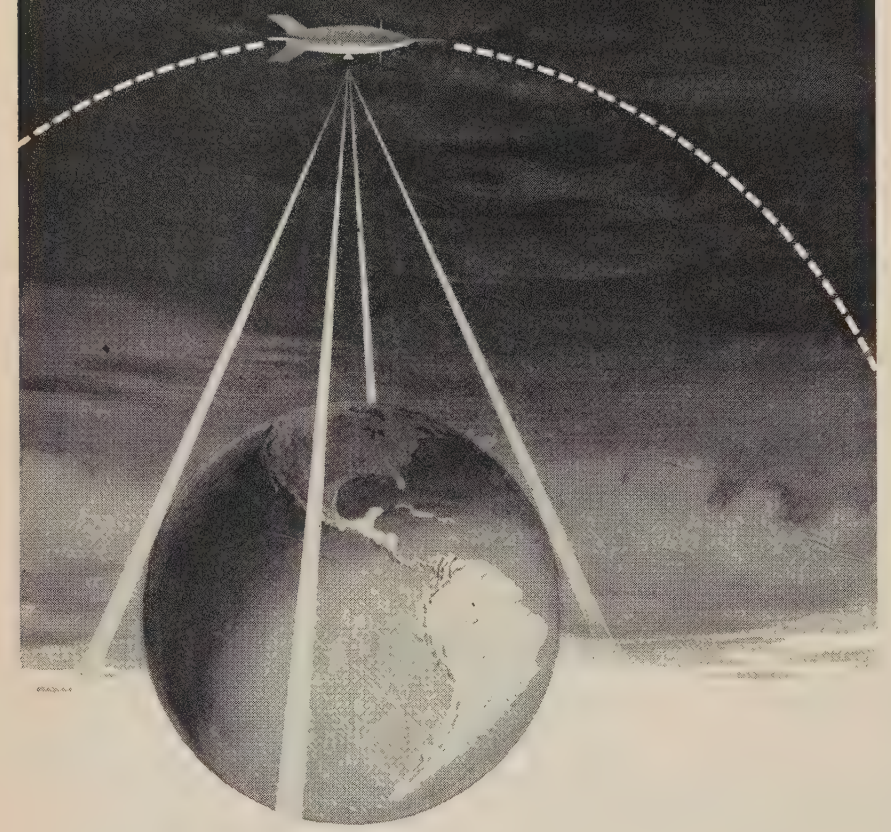
LOOKING FOR

Precision Spatial Reference?



DFI MILITARY SYSTEMS ENGINEERING has led to the development of a true vertical system, guidance command systems, check-out equipment, beacons, radar, and communications systems.

DFI SECONDARY FREQUENCY STANDARDS provide precise reference for vehicle guidance and control. Reliability has been proved on scores of launches.

DFI PROGRAMMERS provide sequence control of pre-determined and/or command events. DfI master sequence controller for satellite vehicle had perfect performance record in every launch.

Write for particulars about DfI capabilities—or telephone collect for prompt, personal attention to your requirements.

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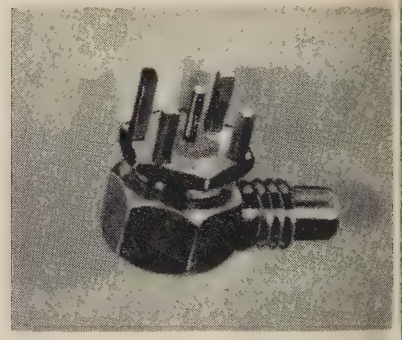
SERVO AMPLIFIER has high gain

Model 130 transistorized servo amplifier will drive either a 3.5 W or 6 W servo motor from low level 400 cps signals. Maximum gain is 2000 and may be adjusted by external resistor, says **Control Technology Co. Dept. S/A, 1186 Broadway, New York 1, N.Y.**

Gain stability is 3 db over the entire temperature range. Input impedance is a minimum of 100 K at all gains and the isolated input makes the amplifier ideal for all computing applications as well as servo designs.

Write in No. 295 on Reader Service Card

COAX RECEPTACLE for printed wiring



This right-angle coax receptacle for printed-wiring boards, type 3008, has a body made of hex stock with four milled studs of rectangular cross section by which the receptacle is attached to the wiring board by dip soldering. It has a one-piece contact with a long turn 90° bend insuring a uniform cross sectional area without distortion which might affect the electrical characteristics and without soldered joints, says **Sealectro Corp., Dept. S/A, 610 Fayette Ave., Mamaroneck, N. Y.**

The main insulator follows the contact around the 90° bend, providing a uniform dielectric thickness on all sides of the contact.

Write in No. 296 on Reader Service Card

CASTINGS from new process

These castings of the permanent mold type are accomplished by a heat transfer system that makes possible applications to exotic metals, aluminum, magnesium, and steel. They are said to be essentially stress free by **Niforge Corp., Dept. S/A, 677 Beacon St., Boston 5, Mass.** The illustration shows application in the manufacture of data processing equipment where precision tape reels of high strength and high stability of dimensions are paramount.

Applications have included parts for missiles, airframes, hydraulic pumps, electronic equipment and other critical assemblies.

Write in No. 297 on Reader Service Card

more on page 238

Multi-Use Automated Maintenance

MPTE

The recent demonstration of multi-purpose test equipment (MPTE), developed by RCA under a series of Army Ordnance contracts, highlights *a new dimension in automated multi-use systems support* and culminates a long-term RCA effort in this field. This General Evaluation Equipment is an automated, transistorized, dynamic checkout system. It contains a completely modularized array of electronic and mechanical evaluation equipment, capable of checking a variety of electromechanical devices, ranging from radar subassemblies to missile guidance computers. MPTE provides the stimuli, programming, control, measurement and test functions for the NIKE AJAX, NIKE HERCULES, LACROSSE, HAWK and CORPORAL missile systems and has been extended to other weapons systems related to our defense efforts.

RCA Tmk(s)®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, NEW JERSEY

Name Your Application!

Do It Better With *Thermo Electric* Thermocouple Extension Cables and Wires

You can obtain Thermo Electric thermocouple extension wire and cable in the widest variety of size, insulation, type and calibration, for your application—with prompt delivery of all standard materials.

New on the stock list, is the time and labor saving "Thermo-Cable," from 6 to 56 matched pairs of I.S.A. color-coded thermocouple leads, individually insulated in PVC—collectively wrapped in "Mylar" aluminum-backed tape—with a tight-fitting PVC outer sheath. "Thermo-Cable" is practically impervious to moisture, abrasion, temperature, gasses and chemicals. Saves you the time, cost and effort of pulling individual wires through conduit.

Individual or duplex thermocouple and extension wires are available in all standard calibrations—many in gages from 14 to 40—insulated with Polyvinyl Chloride, cotton lacquer, Nylon, Teflon, Fiberglass, Asbestos or combinations of these materials. Metallic overbraids of stainless steel and other high-temperature materials provide extra mechanical protection and shielding.

"Ceramo", Thermo Electric's metal-sheathed ceramic insulated thermocouple wire is used for extra-high temperature and nuclear applications.

Thermo-Electric also supplies thermocouple wires to meet Mil-Spec requirements.

For information on selecting the right wire for your application,

write today for Bulletin 32-W5-2

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

Write in No. 139 on Reader Service Card at start of Product Preview Section

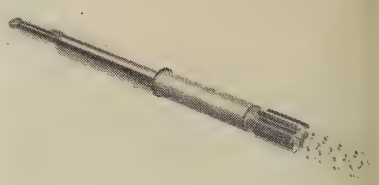
AIR CLUTCH has adjusting disc

This self-adjusting disc type, low inertia air clutch operates on controlled air pressure and uniformly engages a full 360 deg of friction surface, according to **Federal Press Co., Dept. S/A, Elkhart, Ind.**

It delivers full torque at all times.

Write in No. 298 on Reader Service Card

CUTTING TOOLS from new process



These cutting tools are made up by use of a pre-formed metal wafer construction. The wafers are fabricated with the major geometrical configurations of cutting tools already incorporated into their design. They are assembled on arbors of various sizes corresponding to standard sizes, lengths and styles of tools already in use, according to **Spiral Carbide Tool Co., Dept. S/A, 12931 Artesian St., Detroit 23, Mich.** Either HSS or carbide cutting tips are placed into appropriate cutouts and the entire assembly is then brazed into a solid mass as part of the different process employed.

Improved tool performance is said to be due to increased density of the new tool and it is claimed that lower initial and replacement costs for tools results.

Write in No. 299 on Reader Service Card

CONNECTORS have rugged design

The Bantam miniature connectors are capable of dependable electrical and mechanical performance despite extreme temperature and vibration conditions, according to **The H. H. Buggie Div., The Burndy Corp., Dept. S/A, Toledo, O.** The units, which meet MIL-C-26482 (ASG) specifications, are interchangeable with other miniature connectors.

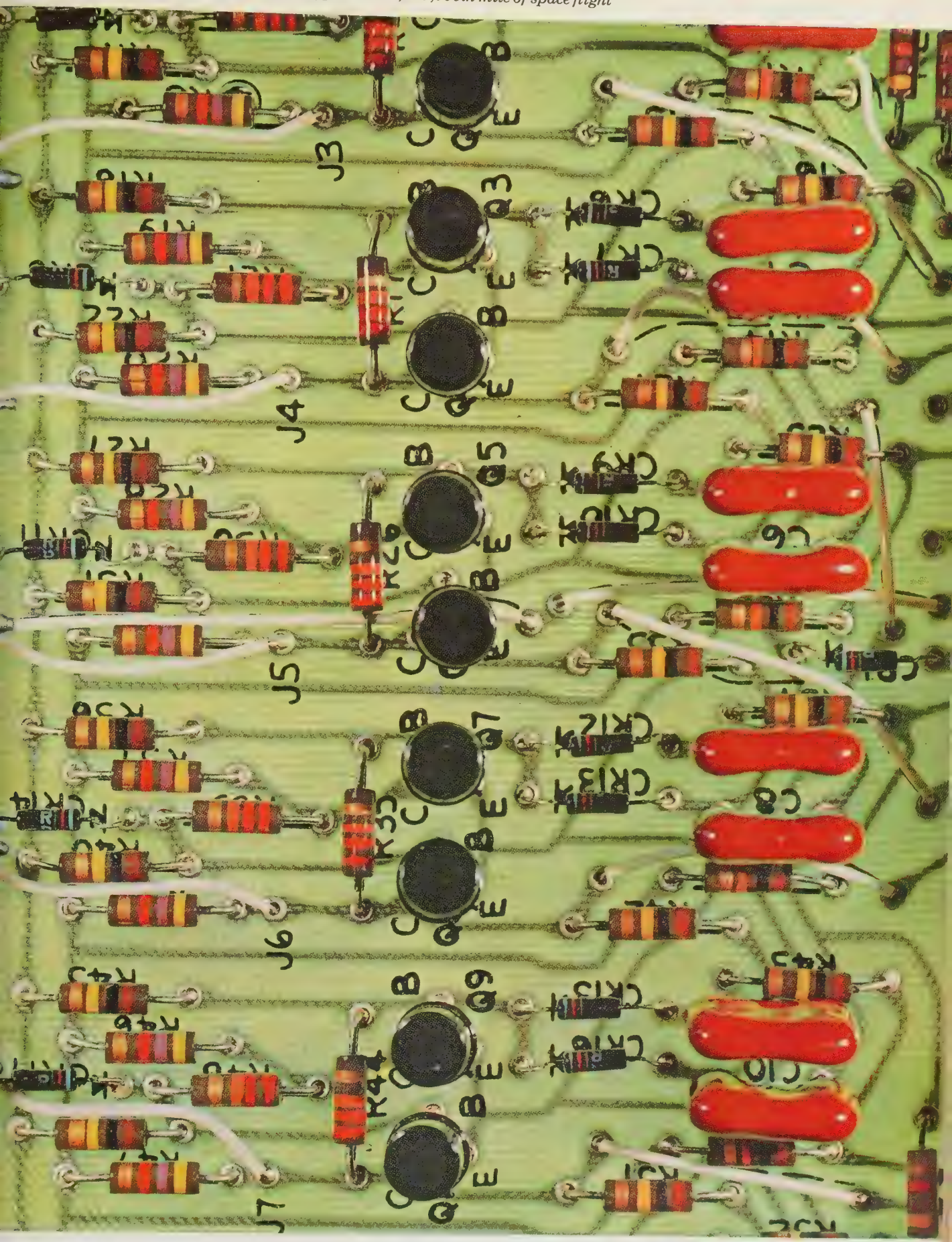
The electronic connectors have gold-plated copper alloy, closed-entry contacts that are embedded in moisture-proof resilient inserts housed in high-tensile cadmium-plated aluminum shells. Heavy spring tension makes for interface sealing that excludes moisture. The line includes general-purpose connectors with threaded aluminum back shells, as well as potting boot open wire seal and cable clamp types.

Write in No. 300 on Reader Service Card

more on page 241

Write in No. 140 on Reader Service Card

00h00m01s GMT March 1, 1960, Martin logged its 457,080,000th mile of space flight



hout electronics it is impossible to design, build, test, ch, guide, track or communicate with a missile. That is why of Martin's 7,500 engineers are electronic/electrical engineers.

MARTIN

CLAMPS by WITTEK

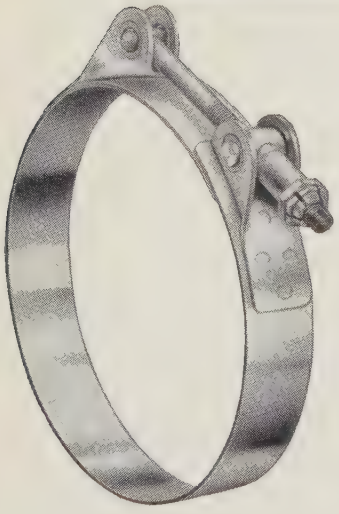
for the *Space-Age*

STAINLESS STEEL FLAT BAND CLAMPS

Complete range of sizes from 2¼" to 10" diameter

Quick-Latch Clamp—Series 10QL

Meets rigid military standards where easy installation and removal are important. The patented latch construction gives positive assurance against accidental disconnect. Basic materials and components meet MS requirements governing Part MS21920R.



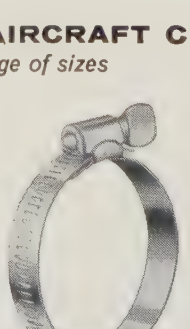
T-Bolt Clamp—Series 10T

Same as 10QL but without patented quick-latch, and recommended for more permanent applications. Meets MS requirements governing Part MS21920.

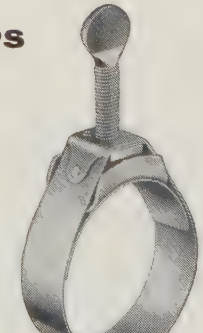
STAINLESS STEEL AIRCRAFT CLAMPS

Complete range of sizes

Type AN737-TW (with shoe)



Type AN737-TWLS (without shoe)



Type AN737-RM (floating bridge)

Descriptive literature or recommendations for any clamping requirements upon request.

Quality Clamps for over a Quarter Century

WITTEK MANUFACTURING CO.

4368 West 24th Place, Chicago 23, Illinois

CLAMPS for Every Application

8825

Write in No. 187 on Reader Service Card at start of Product Preview Section

PRECISION RESISTORS are low cost

These mass-produced, etched precision resistors can replace complete assemblies of conventional precision resistors with a savings of up to 50 per cent in cost and space, says **Photocircuits Corp., Dept. S/A, 31 Sea Cliff Ave., Glen Cove, N.Y.** A new technique permits fine adjustment of the resistor after etching.

The resistors can withstand power dissipations up to 15 W and may be produced with a built-in aluminum heat sink. Resistive values of ten ohms and over, with 0.5 per cent tolerance, can be achieved, as can production of about 100 ohms per sq in. of board area, per side. The units will withstand 100 per cent overloads without ill effect and are humidity resistant.

Write in No. 406 on Reader Service Card

TRANSDUCER for actuator equipment

This potentiometer-type transducer is used in actuator equipment to monitor gas pressure changes during flight testing. It measures the degree of pressure change in the hydraulic system, relaying the information during the ground checkout, according to **Servonic Instruments, Inc., Dept. S/A, 640 Terminal Way, Costa Mesa. Calif.** The data is telemetered to ground recording stations.

Critical elements of the H-90 are completely isolated and sealed in oil within a rugged alloy case. The unit is said to have a range of 0-3500 psig; weighs 5 ozs; measures 1x2¼ in has a linearity of ±0.5 per cent; less than 1 per cent hysteresis; vibration to 20 G; temperature range —65 degree F. to +275 degree F.

Write in No. 407 on Reader Service Card

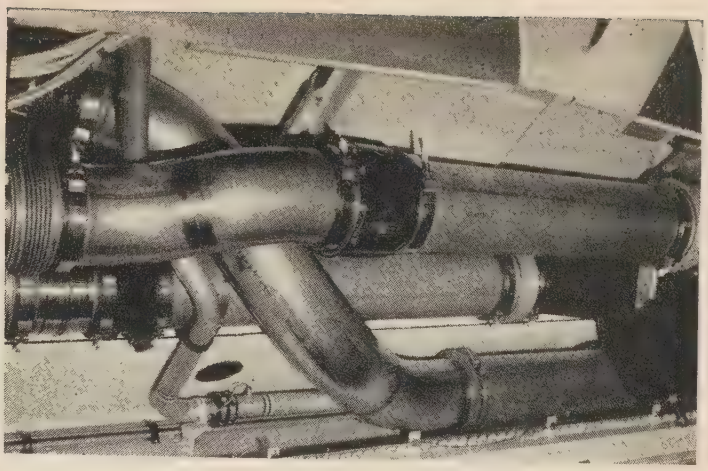
SOLENOID VALVE is pilot-operated

This no-lead, two-way, pilot-operated solenoid valve for controlling the flow of hydraulic fluid MIL-O-5606 and similar liquids. It features low power consumption, fast positive response and low pressure drop. Of cartridge type construction, the continuous-duty solenoid may be quickly removed for maintenance, says **Fluid Regulators Corp., Dept. S/A, 313 Gillette St., Painesville, Ohio.** The valve operates on 0.185 amp, 25 vdc. Operating pressure is 3000 psi. Temperature range is —65 deg F to +275 deg F.

Test specs call for a proof pressure of 4500 psi, a burst pressure of 7000 psi, zero internal and external leakage. It is 4.53 in high, 2.63 in long and 1.25 in wide, and weighs 8 ozs.

Write in No. 408 on Reader Service Card

more on page 242



170 couplings for the 707

Many cities of the world have come closer together in the short year since the Boeing 707 was put in transatlantic service by Pan American World Airways, October 25, 1958.

Janitrol duct couplings have contributed to the history-making performance of this famous jet transport. The aircraft's wing anti-icing, air conditioning, and engine air extraction systems use an impressive number of Janitrol couplings.

The unique capabilities in Janitrol's design and production of couplings, pneumatic controls, heat exchangers, and related components and subsystems are fully described in a new brochure entitled "Janitrol Resources." You are invited to write for a copy, on your letterhead, please. Janitrol Aircraft, a division of Midland-Ross Corporation, 4200 Surface Road, Columbus 4, Ohio, BRoadway 6-3561.

JANITROL®

eumatic controls • duct couplings and supports • heat exchangers • combustion equipment for aircraft, missiles, ground support

Write in No. 188 on Reader Service Card at start of Product Preview Section

THERMAL SWITCH for high temperatures

This hermetically sealed thermal switch is for super-high temperature and can be calibrated up to 1750 deg F. The minimum calibration temperature is −20 deg F. It is a probe type unit with an A/N 10 SL4P connector head, says **Control Products, Inc., Dept. S/A, 306 Sussex St., Harrison, N. J.** The 10SL4S socket with which the unit connects is the smallest A/N two wire connector.

Contacts may close on rise or on fall in temperature. Tolerance is 2 deg F; differential and repeatability for a given switch is 1 deg F, while overshoot to 2000 deg F or an undershoot to −100 deg F can be tolerated without damage to the unit.

Write in No. 301 on Reader Service Card

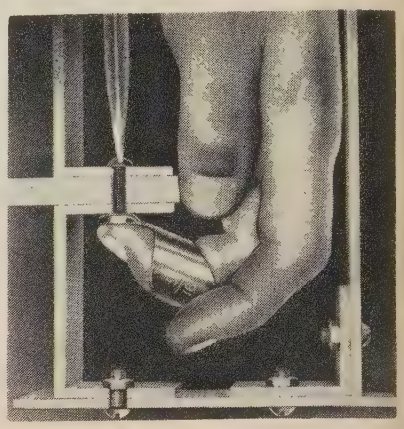
MOTOR SWITCH for missiles

This motor driven switch designed for switching functions on missiles incorporates 5 pdt power circuits, a position indication circuit, and ruggedized solder terminals. The power circuits are rated for currents ranging from microamps to 22 amps. The unit has been successfully tested to 40 G's vibration (to 2000 cycles per second) with no contact chatter, as well as temperatures from −65 deg F to 165 deg F, says **Kinetics Corp., Dept. S/A, 410 So. Cedros Ave., Solana Beach, Calif.** It will maintain positive position stability without control power.

Tests show less than 150 millivolts drop at 22 amps, it is said, and with one milliamp current through the switch at one volt potential, the voltage drop is less than 15 microvolts.

Write in No. 302 on Reader Service Card

TINY WRENCH aids bolt positioning



A small tool that is worn like a ring permits its user to reach into snug, remote or hidden working areas and position a nut or bolt for easy assembly or disassembly, according to **Beaver Tool Co., Dept. S/A, P. O. Box 256, Huntington Station, N.Y.** The Touch 'n Hold wrench does not restrict the free motion of the hands or fingers.

Wrenches are available in the most popular hex head sizes, and they may be adjusted to fit the finger.

Write in No. 303 on Reader Service Card

SATELLITE CENTER U.S.A.

This is the home of Lockheed's advanced Satellite Systems organization. It houses the 2,500 scientists, engineers, and technicians who build satellites for the Discoverer, MIDAS, and SAMOS programs of the U.S. Air Force. Here, under one 346,000-square-foot roof, is America's largest satellite center.

LOCKHEED

MISSILES & SPACE DIVISION

Sunnyvale, California

SNAP-ACTING SWITCH for high temperatures

This subminiature snap - acting switch, type USM4, withstands continued use at temperatures up to 400 deg F. It is only $^{25}/_{32}$ in. long by ¼ in. wide by ½ in. high, permitting them to be gang mounted, four to the inch, for multiple-circuit control in miniaturized apparatus, says **Unimax Switch Div., W. L. Maxson Corp., Dept. S/A, Ives Rd., Wallingford, Conn.**

Besides the basic, pin-actuator style, the USM4 switch can be furnished with leaf or leaf-roller actuator, preadjusted and mechanically locked in the switch assembly during manufacture. The electrical ratings of this single-pole, double-throw switch are: 2.5 amperes, 30V dc, inductive; five amperes, 30V dc, resistive; and five amperes, 125/250V ac.

Write in No. 304 on Reader Service Card

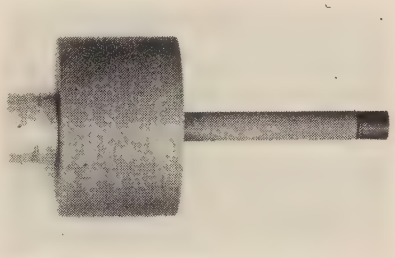
GAS SUPPLY is portable

This automatic gas supply system pumps liquefied gases at pressures up to 12,000 psig and stores the gas at room temperature after passing through a vaporizer. Model PLG-11-6 is a single cylinder, vertical pump complete with liquid nitrogen storage vessel and all controls necessary for automatic operation, says **Dynamic Research, Inc., Dept. S/A, 6701 Sepulveda Blvd., Los Angeles, Calif.** It provides a continuous supply of regulated 6000 psig nitrogen gas at flow rates up to 5 standard cubic feet per minute.

The system measures 30x36x 22 in, weighs 400 lb dry and 450 lb filled, LN2. It is cabinet mounted and easily portable on casters.

Write in No. 305 on Reader Service Card

LIGHTWEIGHT DETECTOR measures cryogenic levels



The liquid levels of all cryogenic fluids can be measured to .050 in. with a small heat sink detector that weighs five oz, according to **Cryogenics, Inc., Dept. S/A, P. O. Box 1919, Pompano Beach, Fla.** The detector interjects no energy or matter directly into the cryogenic medium.

It is recommended for the missile, aircraft, chemical and other industrial fields, and it can be used in both airborne and ground situations.

Write in No. 306 on Reader Service Card

SMALL TUBING for high temperatures

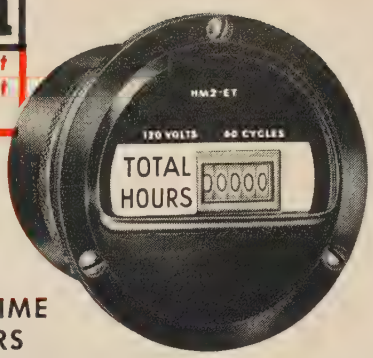
Small tubing of A-286, an austenitic alloy of approximately 55 per cent iron, 25 per cent nickel and 15 per cent chromium, cold-drawn, is being offered commercially for high temperature applications. It was developed for applications where high strength is required at temperatures from 1000 deg to 1300 deg F. Oxidation resistance equals that of AISI type 310 stainless steel at temperatures up to 1800 deg F, it is said by **Superior Tube Co., Dept. S/A, 1902 Germantown Ave., Norristown, Pa.** On engine tests lasting over 500 hours up to 1300 deg F, it shows excellent corrosion resistance against all atmospheres encountered in gas turbine service.

The alloy has outstanding properties at sub-zero temperatures and low magnetic permeability.

Write in No. 307 on Reader Service Card

more on next page

marion
advancement in instrument design



SEALED ELAPSED TIME INDICATORS

SCHEDULE MAINTENANCE — STUDY PRODUCTIVITY

Glass-to-metal sealed ELAPSED TIME indicators. Compact, low cost, tamper-proof. Standard ASA/MIL dimensions, 2½" and 3½" sizes. Easy to read standard size counter registers 1/10 hour steps to 9999.9 or hour steps to 99999. Hermetically sealed. Shielded. Starts, operates continuously from — 55°C to +85°C. For 110-125 or 220-250 volts 60 cycle AC. Bulletin on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, N. H., U.S.A. *In Canada, Honeywell Controls Limited, Toronto 17, Ontario.*

Honeywell

75th YEAR PIONEERING THE FUTURE First in Control SINCE 1885

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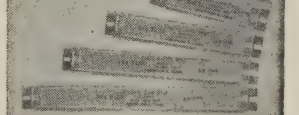
New
POWER RESISTORS
for FLIGHT USE

ELECTRO-FLEX

specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

send for free illustrated booklet

Electro-Flex Heat, INC.

83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)

"FIRST with STANDARD ELEMENTS"

Write in No. 191 on Reader Service Card

DC AMPLIFIERS have transistor choppers

These low-noise, solid-state amplifiers make up the first available line of such devices with transistor choppers, according to **Packard Bell Computer Corp., Dept. S/A, 1905 S. Armacost Ave., Los Angeles 25, Calif.** The design, which is offered in wide-band differential, operational and potentiometric amplifiers for data handling systems, contributes to amplifier and system reliability.

The differential amplifiers are available with input impedances up to 10,000 meg and a common mode rejection of 120 db at dc. Noise is in the microvolt region. All three amplifier types offer a frequency response exceeding minus three db at 200 kc. Gain accuracies, linearity and drift figures are better than .002 per cent in most models, and noise is under .01 per cent, peak to peak, from any source. The 8 x 4 x 1½-in. units have self-contained power supplies.

Write in No. 308 on Reader Service Card

MAGNET MOTORS weigh 0.26-0.43 lb

These 1¼ in. diameter permanent magnet d c motors in three frame lengths with standard mounting holes to fit most applications are designed to meet MIL-M-8609 (ASG) requirements. Armatures wound for voltages from 6 Vdc to 115 Vdc. 14-bar commutator and 14-coil armature insure low motor ripple, says **Barber-Colman Co., Dept. S/A, Rockford, Ill.** Constant tension springs provide uniform radial pressure over entire motor life.

Normal ambient temperature range is —65 deg to 200 deg F; custom designed units will withstand +400 deg F or —100 deg F.

Write in No. 309 on Reader Service Card

MULTICODERS use solid state circuitry

A series of low level telemetry multicoders, designed to withstand missile environments, and featuring all solid state circuitry, are available from **Applied Electronics Corp., Dept S/A, P. O. Box 43, Metuchen, N. J.** The devices may be obtained in any standard IRIG switching configuration for PAM and PDM systems.

A standard form of sampling switch with an electronic speed regulator is used by the multicoders, and no power inverter is required. Maximum sensitivity of the units is ten mv for full scale output and common mode signal rejection is ±50 V dc to plus or minus ten V at 1000 cps for one per cent of full scale error. A mixed high and low level system is available for 90 channels, and a synchronized electronic commutator is used for the high level section. Weight of a multicoder is 2¾ lbs, and volume is 35 cu in.

Write in No. 440 on Reader Service Card

PHASE-SHIFT CONTROL for rectifier

The silicontrol provides sharp pulses of constant amplitude in 180 deg variable phase angle to control the rectifier output proportionately from 0 to maximum with but a one to 2 milliwatt dc signal. Its four control linings are isolated from the rectifier power circuits, and loss of the control signal turns off the rectifier, says **Vec Trol Engineering, Inc., Dept. S/A, P. O. Box 1089, Stamford, Conn.**

The constant amplitude output is of vital importance when driving the silicon rectifier because any overdrive, however transient, can and usually does destroy the rectifier. Both linear and fail-safe in operation, the silicontrol has a time constant of 1 millisecond for control current change and one unit will control ½ wave or two full wave silicon control rectifiers.

Write in No. 441 on Reader Service Card

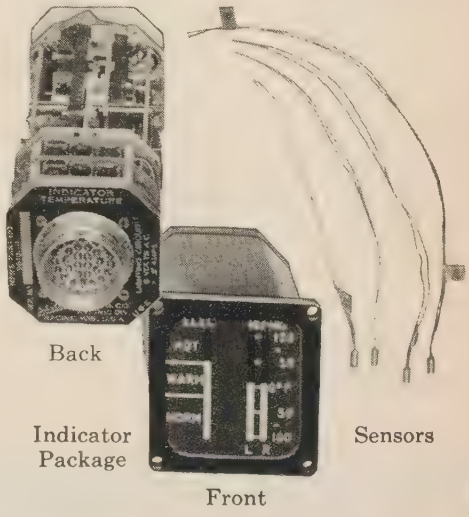
more on page 24

1 or 6 . . .

How do you take the temperature of an electronic system?

Use ONE Compact, Accurate, Lightweight, Completely Transistorized Oster-Developed Temperature Indicating System. Replaces 6 Indicating Systems.

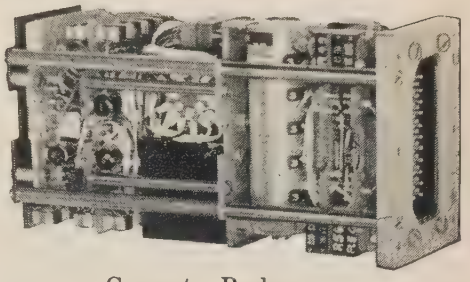
The device illustrated senses and displays the highest of 4 temperature sensor signals on the Convair B-58 supersonic bomber. It also reads out the temperature of the plane's 2 refrigeration systems. However, the unit can monitor temperature of any military or commercial electronic system. Special versions can be furnished to monitor any analog voltage signal.



Oster®

Entire unit (component parts illustrated) has an accuracy of 1½%, weighs only 3.85 lbs. max., requires only 2⅜" panel space, and does the work of 6 indicating systems. Component parts consist of 4 sensors, a computer package with 6 channels, and a hermetically sealed indicator package.

The unit is typical of Oster designed equipment.



Computer Package

For help with your instrumentation and display problems, talk to the specialists at the Avionic Division.

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OTHER PRODUCTS INCLUDE:

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Specialists in Instrumentation and Display
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Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms.
Contact Mr. Robert Burns, Personnel Manager, in confidence.

Write in No. 193 on Reader Service Card at start of Product Preview Section

Controlled atmosphere furnace takes parts 70" dia. by 112" high

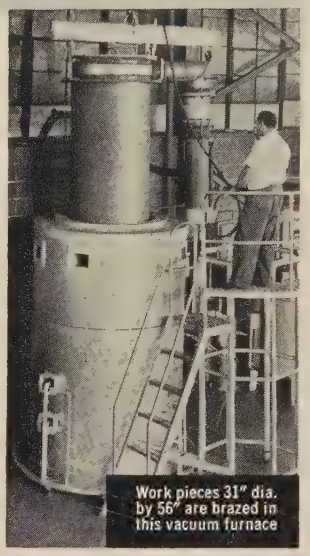
Ask for Special Help When Brazing Stainless

Silver brazed titanium heat exchanger, done in a vacuum furnace

Ask us for help in deciding how to best braze your stainless alloy assemblies. We successfully braze almost every known stainless steel, superalloy, and aluminum or titanium bearing metal.

Ask us to choose the best brazing alloy from the massive array of copper, silver, and nickel base alloys available. We know and use them all.

Ask us for a quotation on doing your stainless brazing or heat processing. Our pencils are sharp and so are the four furnace plants we operate to serve you.


Work pieces 31" dia. by 56" are brazed in this vacuum furnace

WALL COLMONOY CORPORATION
Stainless Processing Division
19345 John R Street • Detroit 3, Michigan
Wall Colmonoy furnace plants are maintained in Michigan, Pennsylvania, Ohio, and California

Write in No. 194 on Reader Service Card at start of Product Preview Section

REGULATORS for dc generators

This pair of transistorized voltage regulators for aircraft dc generators provide a response rate five times greater than carbon-piles, and offer a ten-fold extension of operational life, estimated to be 10,000 hours, says **Hydro-Aire Co. Dept. S/A, 300 Winona Ave., Burbank, Calif.** Being a solid state device, they have no moving parts and require no shock mounting.

These regulators can be set to any value between 26 and 30 volts in increments of 0.05 volts.

Write in No. 310 on Reader Service Card

more on page 250

TELEFLIGHT®

NEW Model 181
AIRBORNE PRESSURE TRANSDUCER

Now a NEW Taber TELEFLIGHT, weighing less than 12 ounces has been designed with an adapter that permits an amplifier to be built in to increase output signal to five volts as used in telemetering systems. BONDED STRAIN GAGE construction makes it relatively insensitive to vibration or shock. Resolution is INFINITE. Handles extremely corrosive media, including fuming NITRIC ACID. Features Pressure Cavity clean-out and standard built-in pressure overload protection. Pressure ranges: 0-250, 0-350, 0-500, 0-750, 0-1,000 PSI. Linearity 0.3%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature —100° F. to +275° F.

Taber also produces a complete line of Miniature Transistor Amplifiers. Voltage, Power, Servo & Audio Amplifiers also available.

Write or telephone for literature and prices.

TABER INSTRUMENT CORPORATION
Section 36 107 Goundry St.
North Tonawanda, N. Y.
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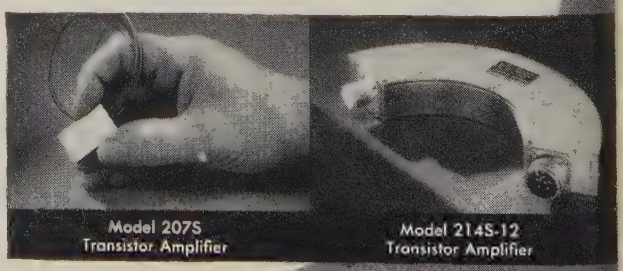

Model 207S Transistor Amplifier
Model 214S-12 Transistor Amplifier

Write in No. 195 on Reader Service Card at start of Product Preview Section

And SAFEWAY Heating Blankets and Elements solve cold problems wherever they exist!

Maybe it's a basic defrosting problem in industrial refrigeration . . . or perhaps it involves the vital protection of aircraft from the icy upper atmospheres.

For these and scores of in-between applications, Safeway provides a *controlled heat* product, regardless of environmental temperatures. And people who know refrigeration depend on Safeway Heat Elements as a completely reliable and economical solution to defrosting problems in the commercial and industrial field.

Safeway's modern manufacturing facilities are devoted *exclusively* to the design, engineering and application of *controlled heat* for industry. Among the wide variety of Safeway heating blankets, woven and molded heating elements are:

- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **de-icing units for airfoil surfaces**
- **heating elements for all types of ground support equipment**
- **defrosting units for industrial and commercial refrigeration**
- **heating blankets for honeycomb and metal-to-metal bonding**

For your copy of a fact-filled folder, please write:

it has to be heated (and the "it" can just about anything), you can rely on FEWAY engineers to study your prob- ns carefully, and—without any obligation ubmit an appropriate recommendation.

Safeway HEAT ELEMENTS INC.

Middlefield Street • Middletown, Connecticut

Write in No. 196 on Reader Service Card at start of Product Preview Section

working

machine's decision–space

The final launching decision for future space vehicles will probably be made by electronic logic devices—far faster, far more precise and far more reliable for this purpose than the human brain. Resistor-transistor circuit modules are the basic elements of the "decision machine."

Such devices are the pre-launch test units developed by Honeywell's Aeronautical Division for validating its stabilization control systems. They check the orientation systems in a space vehicle; a simple GO or NO GO signal diagnoses malfunctions and identifies the offending systems.

The pre-launch checker is another example of the Aeronautical Division's interest in controls. Other developments include adaptive flight control systems, electrically suspended gyros and environmental control systems for space vehicles.

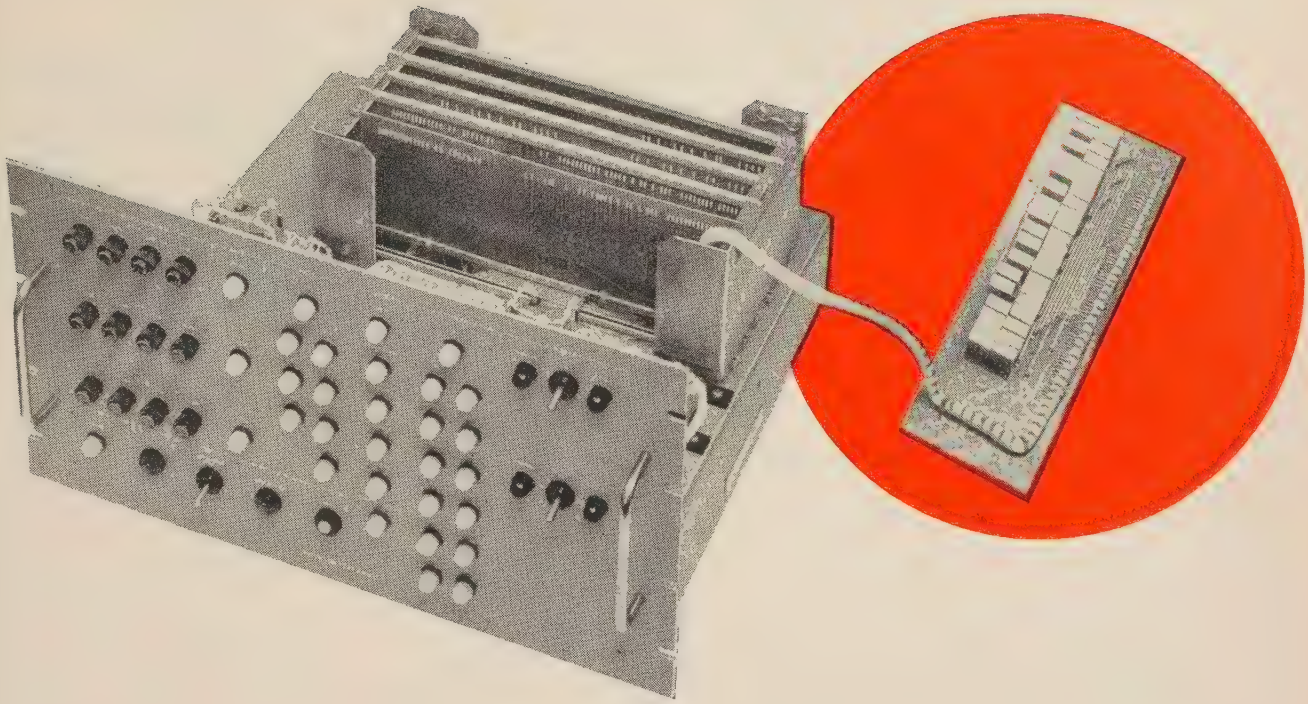
Honeywell has made contributions to Scout, Sergeant, Thor, Atlas, Titan, Mercury, F-104, B-58, X-15, WS117L, Polaris and many others. Current expansion has created openings for senior and junior engineers and scientists in these and similar programs. Your inquiry will get prompt and confidential attention.

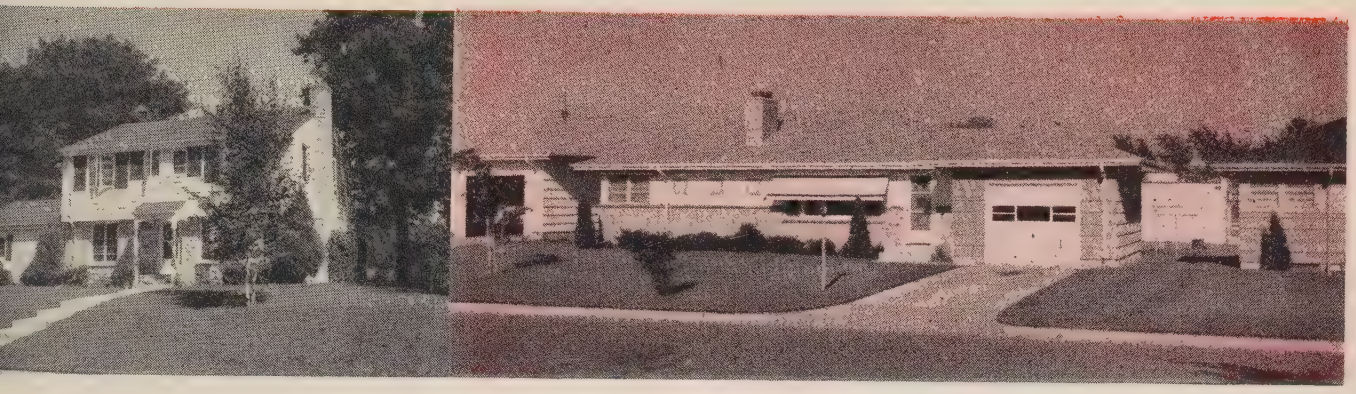
man's decision–place

living

Honeywell engineers make their own decisions on where to live—in the city, the country or the suburbs. Most live in or near the Twin Cities—an area where work is typically 20 minutes from home, where nearly every yard is big enough for outdoor entertaining. People here are sports minded, and there are participant and spectator activities to appeal to all.

Minnesota is characterized by the kind of living which is both enjoyable and healthful. Minnesotans are proud of the fact that they have consistently had the smallest ratio of rejections for the Armed Forces Qualification Test.





The Twin Cities is a cultural and educational enter. It's the home of the Minneapolis Symhony Orchestra. Its Walker Art Center and Minneapolis Institute of Art are famous for heir collections, their progressiveness, their ncouragement of young artists. Public school ystems in the Twin Cities are nationally recogized for their excellence. There are six colleges cated here, including the University of Minesota, which is just two miles from Honeyell Aeronautical.

Honeywell engineers find these are important arts of the good life they enjoy in Minnesota.

For further information on working at Honeywell Aeronautical Division and living in Minneapolis, please send a resume to Bruce D. Wood, Dept. 462A.

Honeywell

AERONAUTICAL DIVISION

1433 STINSON BLVD. N. E. • MINNEAPOLIS 13, MINNESOTA

To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Write in No. 197 on Reader Service Card at start of Product Preview Section

BOMARC pressure system components include RMC-Lindsay Gauges

The Boeing Bomarc, a true "push-button weapon," automatically seeks out and destroys its target. In such a weapon there can be no compromise in the performance requirements for its mechanical and electronic components.

Among these components, RMC-Lindsay "gearless" pressure gauges are employed on two Bomarc assemblies—the ram jet full pressure system and the nose air pressurization system.

RMC-Lindsay gauges withstand shock tests of 100 G's. They are checked for accuracy in vibration tests ranging from 10 to 2,000 cps at 35 G's and at ambient temperatures from −65° F. to +430° F. There is no linkage, no gear train—the indicating pointer is attached directly to the end of the helical bourdon coil. Qualified under MIL-E-5272.

Model #6906
(Half Size)

All RMC-Lindsay gauges are built to the most exacting standards for accurate performance under the most rigorous conditions encountered in modern industry, in jet aviation, in astronautics.

Complete engineering and production facilities are available at RMC for subcontract work in pressure system components—gauges, valves, switches, etc. Write, wire or phone:

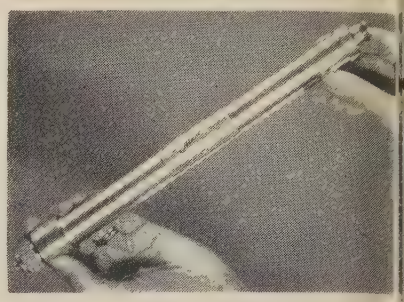
ROCHESTER MFG. CO. OF CALIFORNIA
1401-B So. Shamrock Ave., Monrovia, Cal.

ROCHESTER MANUFACTURING CO., INC.
224 Rockwood Street, Rochester 10, N.Y.

RMC
LINDSAY PRESSURE GAUGES

Write in No. 198 on Reader Service Card at start of Product Preview Section

FERRITES are smaller, lighter

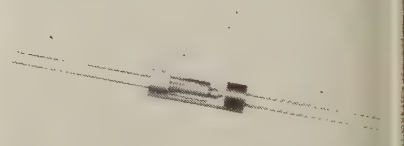


Ferrite components for lighter, more compact radar and microwave circuitry have been announced by **Sperry Rand Corp., Dept. S/A, Great Neck, N.Y.** The new ferrite designs incorporate a compact magnetic field unit small enough to fit inside the coaxial envelope of ferrite isolators.

The internal field unit supplies the necessary magnetic field and controls the ferrite material more effectively than the large, external magnets it replaces. Typical of the weight and size offered by the design are that of an isolator for L-band radars: this unit is 1/5 the weight and 1/10 the volume of its predecessor. "Magnetless" units have been designed for use in radars, countermeasures, communications, missiles, and special test equipment.

Write in No. 311 on Reader Service Card

THERMAL RELAY is low-current type

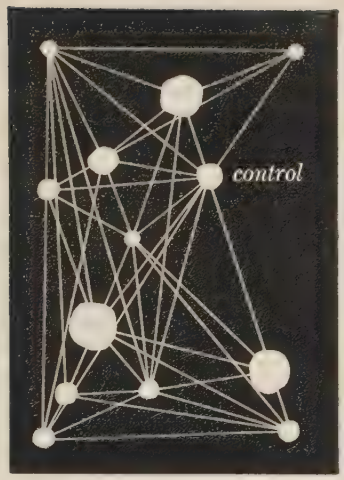


A subminiature thermal relay that can be used as a low-current sensing device or as overload protection in missile circuitry and other electronic equipment has a firing sensitivity of 0.2 amps, says **Networks Electronic Corp., Dept. S/A, 14806 Oxnard St., Van Nuys, Calif.** The Series M555 relay handles a continuous fuse current of .120 amps maximum and a firing current of .180 amps minimum.

Contact rating is one amp. The spst, normally open device is hermetically sealed and has a transparent glass case to permit inspection of all working parts. Characteristics include the ability to operate under a vibration of 20 to 2000 cps at 15 g's and a temperature range of −100 to +400 deg F.

Write in No. 312 on Reader Service Card

more on page 252



professional opportunities at Honeywell Aero

INERTIAL SYSTEM DEVELOPMENT

Systems Analyst—employs mathematical techniques such as operational calculus, matrix algebra, and difference equations to the solution of problems concerning performance characteristics of various system configurations including analysis for error introduced by sensors and computer, requirements for alignment, and optimization of the system configuration.

Digital System and Logic Designer—requires familiarity with capabilities of various digital computer configurations and ability to employ system and logic relations in specifying necessary configuration for solving inertial navigation problem.

Electronic and Mechanical Designers—engineers with background in transistor circuitry, inertial sensor development and evaluation, and precision mechanical equipment design are needed to perform component development and evaluation, and to design mounting and alignment equipment.

APPLIED RESEARCH

Programmer Analyst—mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

Human Factors Engineer—capable of analysis and direction of experiments in human motor skills, and application to man-machine systems involving automatic control techniques.

Systems Analyst—capable of conducting research studies involving new techniques of space navigation and guidance.

DESIGN AND DEVELOPMENT

Flight Control Systems—analytical, systems, and component engineers to work in areas such as advanced flight reference and guidance systems. Positions range from analyzing stability and control problems, systems engineering—through design, testing, and proof of electrical and mechanical equipment—including flight test and production test.

Advanced Gyro Design—Engineers with two and up to twenty years' experience in precision gyro and accelerometer development, servo techniques, digital techniques, solid state electronic development, advanced instrumentation and magnetic component design.

Electronic Circuit Designers—experienced in the areas of analog/digital computers, transistor circuits, servos, instrumentation, and/or gyro stabilization.

For the less experienced professional engineer, there are opportunities in the Evaluation Laboratory which lead to careers in any of the above fields.

To investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Bruce Wood, Dept. 462B

To explore professional opportunities in other Honeywell operations coast to coast, send your application to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Honeywell H HONEYWELL

AERONAUTICAL DIVISION

1433 Stinson Blvd. NE, Minneapolis 13, Minnesota

Check Employment Inquiry Form on Page 165

FOR ABSOLUTE MEASUREMENTS OF CORROSIVE MEDIA

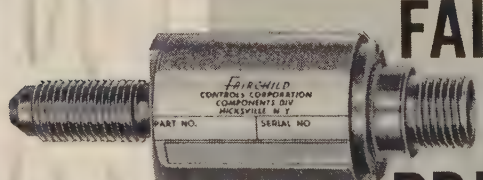
This 1-inch Pressure Transducer takes shock, acceleration, and vibration like no other its size. It was specifically designed to measure pressures of corrosive fuels such as ... red fuming nitric acid (RFNA) and liquid oxygen (LOX). The corrosive media is contained inside a welded stainless steel or NI-Span-C diaphragm. The precision wirewound potentiometer pick-off provides an output signal resolution of 0.25% for most ranges. The TP-100 safely takes up to 100% overpressure with negligible calibration shift. An improved "H" bar linkage between the diaphragm push rod and the pot wiper arm is a major factor in the excellent performance and high reliability of this precision device. All parts are statically and dynamically balanced, the linkage limits the motion and minimizes errors under severe vibration and acceleration conditions.

Write to Dept. 36S

FAIRCHILD CONTROLS CORPORATION
COMPONENTS DIVISION
225 Park Avenue : Hicksville, L. I., N. Y.
6111 E. Washington Blvd. : Los Angeles, Cal.

GYROS
PRESSURE TRANSDUCERS
POTENTIOMETERS
ACCELEROMETERS

A Subsidiary of Fairchild Camera and Instrument Corporation

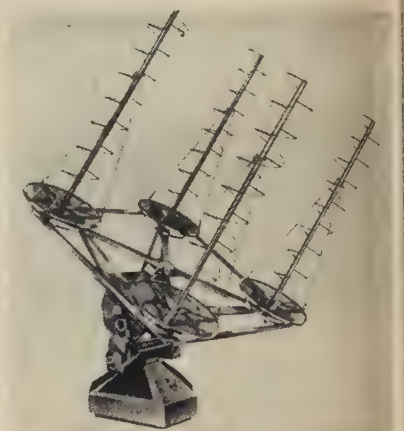


FAIRCHILD TP-100 PRESSURE TRANSDUCER

Specifications and Characteristics

Pressure Range	0-15 to 0-500 psia
Accuracy	Overall band width of ±1.5% including linearity, hysteresis and friction in most pressure ranges
Resolution	0.25% for most ranges
Repeatability	Less than 0.5% depending upon resolution
Vibration	10 to 2000 cps, 15g with less than 1% error 10 to 2000 cps, 35g with less than 2% error
Acceleration	40g with less than 1% error
Shock	100g without damage
Temperature	—54° to +100°C

ANTENNA for telemetry

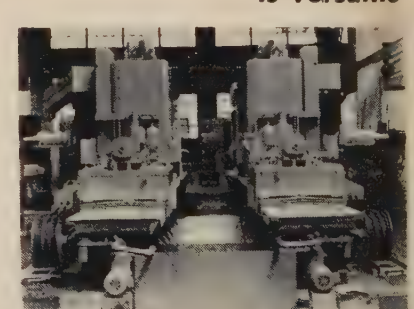


This quad-helix antenna with a 215 to 265 mc range provides reliable telemetry communication between ground stations and in-flight missiles or satellites. The gain of this antenna is 17.5 db at 265 mc. VSWR is less than 2 to 1, says **Andrew Corp., Dept. S/A, 363 E. 75th St., Chicago 19, Ill.**

An easy to control rotator provides for 720 deg azimuth and 180 deg elevation tracking at speeds up to 30 deg per sec.

Write in No. 313 on Reader Service Card

CAVITY MILLER is versatile



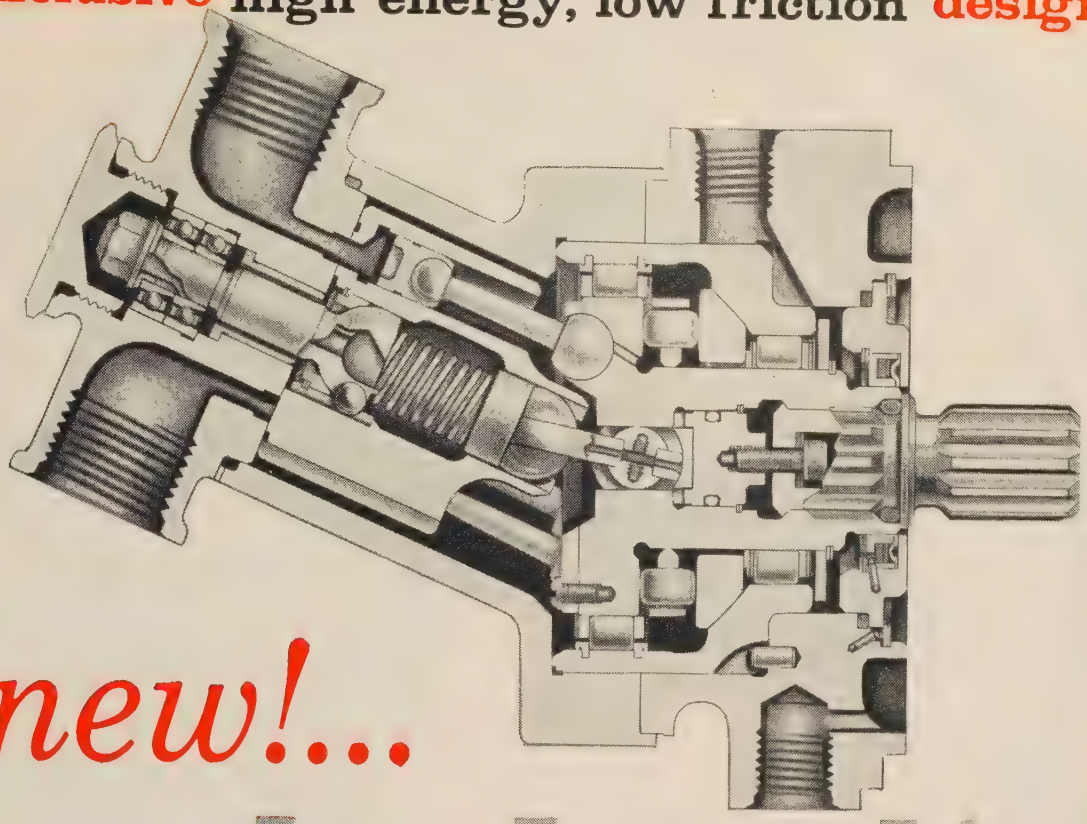
The Farrel-Newton cavity miller, the first machine of its type designed to mill both ferrous and non ferrous metals, can mill opposing sides of work simultaneously, says **Farrel-Birmingham Co., Inc., Dept. S/A, 565 Blossom Rd., Rochester 10, N.Y.** Weight and rigidity of the miller permit it to mill high-alloy steels at slow feeds and speeds.

The machine's two opposed traveling-column milling units may be used independently under either three-dimensional magnetic-tape or manual control, and each unit is available as an open-side machine. The cutting-speed range is 15 to 3600 rpm, and 60-hp adjustable-speed motors drive the spindles. Accuracy is such that tolerances can be held to within ±.0005 to .002 in., depending on the travel rate, and the machine is capable of intricate milling work.

Write in No. 314 on Reader Service Card

more on page 256

exclusive high energy, low friction design



new!... hydraulic motors and pumps

with basically new design features offering basically better performance!

Free — Product Data Bulletin No. 25 describes Cornelius Aero Hydraulics equipment; includes installation information, specifications and performance data. Write today.

Here is important news for hydraulic design engineers. The Cornelius Company is pleased to announce development of a new line of hydraulic motors and pumps that are lighter, more efficient and more compact. The exclusive, new **high energy, low friction** design of this equipment is possible because of Cornelius inventions. Nine U.S. and foreign patents covering these products have been issued to date.

If you have unsolved problems in hydraulic motors and pumps or are not entirely satisfied with the performance you are now getting from your present equipment, be sure to investigate these new Cornelius products. These new Cornelius pumps and motors can be tailored to meet your system requirements.

Pioneers in Pressure Systems for Flight

THE Cornelius COMPANY

AERO DIVISION

553-39th Avenue N. E. • Minneapolis 21, Minnesota

Qualified individuals will find excellent opportunities available in Cornelius engineering and sales departments.

Write in No. 199 on Reader Service Card at start of Product Preview Section

GLOBAL

North

4-wire Crossbar

"Seven League

Switching Boots" for

MILITARY COMMUNICATIONS

The world wide disposition of American strategic and tactical military forces imposes a new necessity for global long-haul communications networks with transmission requirements far exceeding those commonly available in commercial continental networks.

This extension of "lines of communication" makes it mandatory that switching in such networks protect the transmission capabilities gained at such expense.

Two-wire switching centers, with their higher distortion and attenuation characteristics, the inevitable result of the hybridization necessary to accommodate 4-wire transmission links, are eminently unsatisfactory in these long-haul networks.

North 4-wire Crossbar switching systems meet the exacting requirements of long-haul 4-wire networks.

North 4-wire Crossbar switching systems combine inherent versatility, flexibility and expandability with absolute reliability.

North 4-wire Crossbar switching systems have low transmission attenuation and require an absolute minimum of maintenance.

North 4-wire Crossbar switching systems meet minimal spatial requirements and can be used in either fixed or mobile installations.

North 4-wire Crossbar switching, with the register-sender, marker and translation techniques and the alternate routing capability fundamentally inherent in Crossbar switching, has already proven itself in global military networks.

For detailed information, write for
"4-WIRE CROSSBAR SWITCHING SYSTEMS"

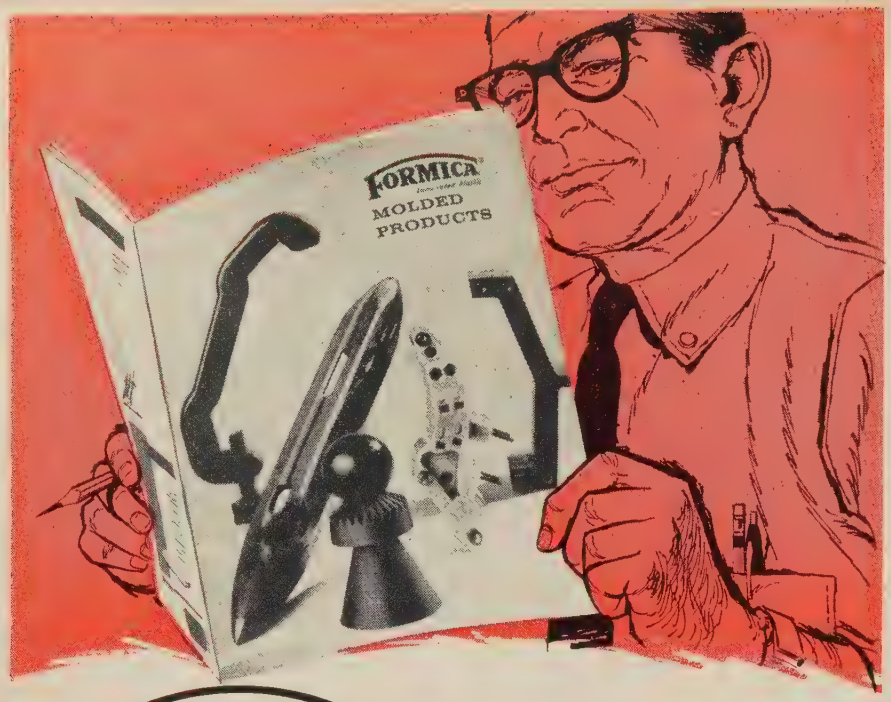
ELECTRONETICS DIVISION

SA-2

NORTH ELECTRIC COMPANY

GALION, OHIO

Write in No. 200 on Reader Service Card at start of Product Preview Section



new FORMICA® molded parts service valuable aid to product designers

It's complete. Includes special design assistance, versatile mold making, unlimited press capacity. Produces molded laminated plastic parts with great mechanical strength, dependable electrical insulation, absolute uniformity, without costly machining. Write for **FREE Bulletin 909.** Formica Corporation, a subsidiary of American Cyanamid, 4538M Spring Grove Ave., Cincinnati 32, Ohio.

FORMICA

a product of CYANAMID

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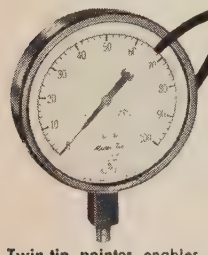


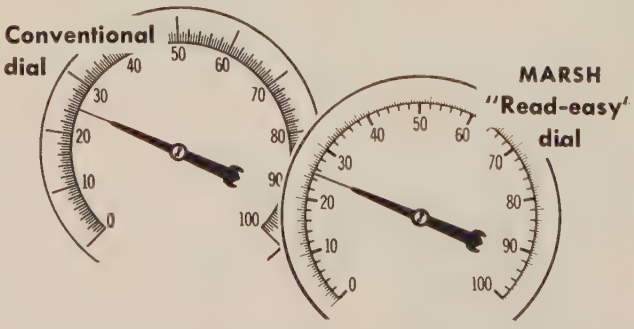
New MARSH "Master Test" SERIES

Unprecedented accuracy and dependability in test gauges developed to meet today's exacting requirements. Each gauge individually *dead-weight tested!* Guaranteed accurate within ¼ of 1% plus or minus of maximum dial reading over entire range.

Twin-tip pointer enables observer to read "dead-on" by lining up twin tips like gun sight.

Mirror dial also insures accurate "dead-on" reading.

"Non-parallax" dial has Plexiglas insert that assures accurate reading even when read at angle.



New "Read-easy" dial (patent pending), as illustrated above, assures reading accuracy in keeping with indicating accuracy. Also note three advanced means of reading available in all "Master-test" gauges: twin-tip pointer, mirror dial, and "non-parallax" dial as shown opposite.

Sizes 4½", 6", 8". All standard pressure ranges 0-15 psi to 0-30,000 psi, vacuum and compound.

Ask for new 20 page bulletin covering all details

MARSH INSTRUMENT CO., Dept. 43, Skokie, Ill.

Division of Colorado Oil and Gas Corporation

Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta

Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Write in No. 202 on Reader Service Card at start of Product Preview Section

SWITCHING TRANSISTOR has fast operation

Total switching speeds of a new diffused-base silicon "mesa" switching transistor are as fast as 25 musec, says **Texas Instruments, Inc., Dept. S/A, P.O. Box 312, Dallas, Texas.** The 2N702 is produced by the gaseous diffusion process for inherently high performance, outstanding reliability, extreme ruggedness, and a dissipation of 150 mw at 100 deg in free air.

The 2N702 has a guaranteed dc beta spread of 15 to 45, and maximum collector cut-off current is 0.5 ua. Maximum saturation voltage is 0.6 V

Write in No. 315 on Reader Service Card

TIME DELAY RELAYS from one to 300 sec

These sub-miniature time delay relays for high-altitude, high-vibration, and high-temperature applications, have a seated height of 1 3/32 in. and weight of ¾ oz. The units are hermetically sealed and show no resonance from five to 1,000 cps at ten g's, are not damaged by 50 g's shock, and are fully compensated for temperatures from —65 to +125 deg C, says **Dialtron Corp., Dept. S/A, 203 Harrison Pl., Brooklyn 37, N.Y.**

The relays are offered in a time range from one to 300 sec and in heater voltages up to 150 V interchangeable on dc or ac of any frequency with a power drain of four watts. Available spdt, normally open or normally closed contacts are rated at six amperes at 115 Vac or three amperes at 28 V dc resistive.

Write in No. 316 on Reader Service Card

SERVO MOTOR has precise control

This 115 V, 60 cycle, size 18 servo motor is a precision control component, engineered to provide the high torque and instantaneous acceleration required for rapid, precise response to minimum control signals. It weighs 15 ozs, has completely encapsulated windings and housing of stainless steel, says **Beckman Instruments, Helipot Div., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** It can be wound for any standard carrier voltage supply, and requires a power input of 9 watts/-phase with 0.64 power factor.

Performance includes no-load speed of 3200 rpm, torque at stall of 4 oz in, and acceleration at stall of 70,000 rad/sec^2. It will operate continuously at stall to unit temperatures of 200 deg C.

Write in No. 317 on Reader Service Card

more on page 260

WRIGHT Quality

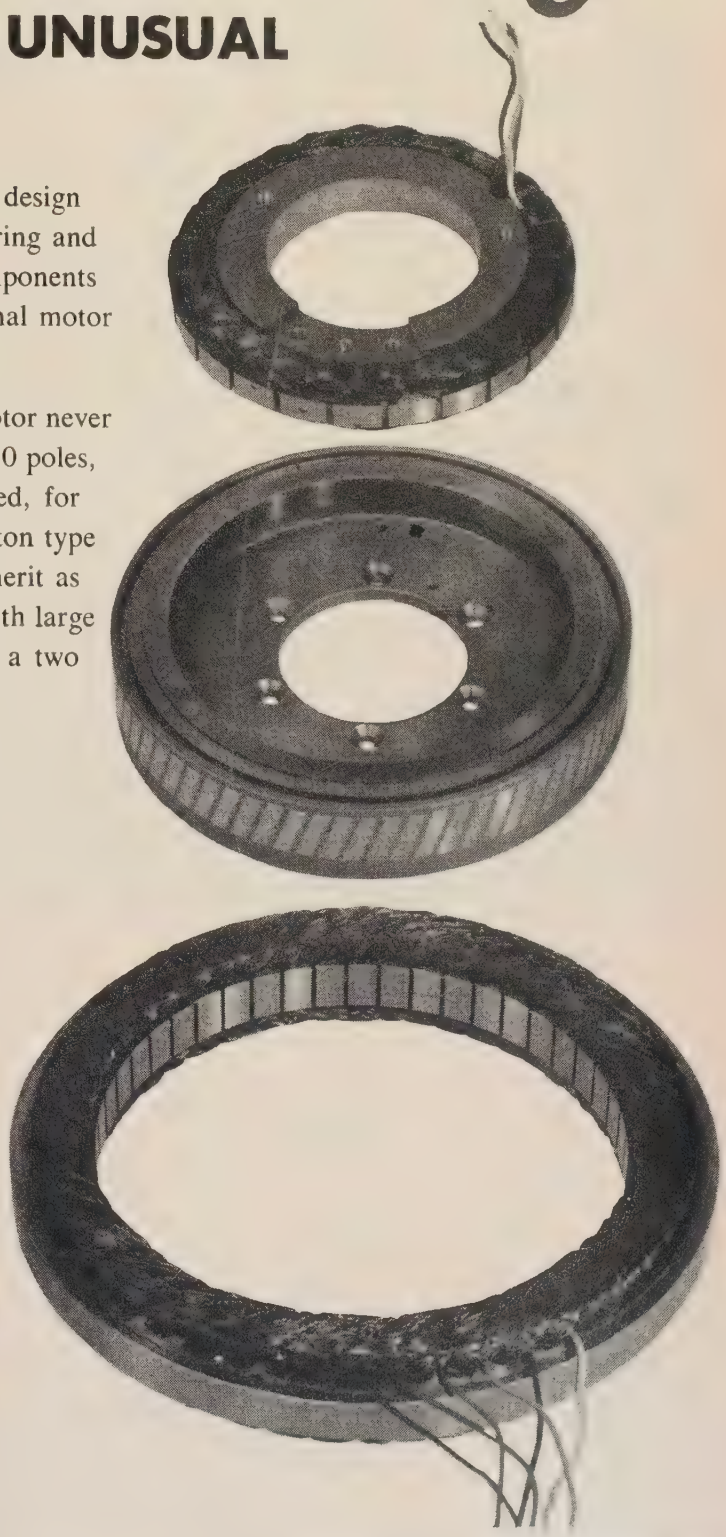
FOR REQUIREMENTS UNUSUAL

These stator and rotor combinations in flat design illustrate Wright Machinery's motor engineering and production capabilities. They are ideal components where the motor is built in and a conventional motor housing is not needed.

One class is the torquer, where the motor never attains running speed. They are made with 20 poles, generally two-phase 400 cycles; and are used, for example, to slave or precess a gyro. A skeleton type multi-pole slow speed servo may have real merit as compared with a high speed control motor with large ratio gearing. Currently, we are producing a two speed motor to operate at 600 and 300 rpm synchrous speeds on 60 cycles.

Another class is for gyro spin motors wherein the stationary wound element is inside, and the rotor is embodied in a fly wheel for high inertia. Wright "pancake" type units can also be supplied as synchros and resolvers.

If your precision motor requirements go beyond the catalog type, consult Sperry Rand's Wright Machinery division.



WRIGHT MACHINERY COMPANY
DIVISION OF SPERRY RAND CORPORATION
DURHAM, NORTH CAROLINA

SALES OFFICES in Durham, N. C.; New Hyde Park, Long Island, N. Y.; and El Segundo, Calif.

Write in No. 203 on Reader Service Card at start of Product Preview Section

...with R/M Style 41RPD asbestos-phenolic felts

Motor-tube insulation liners and other high-temperature asbestos-phenolic parts are natural applications for R/M Pyrotex® felts and tapes.

Wrapped by a variety of techniques, tubes of R/M Style 41RPD Pyrotex tape can be fabricated into one-piece (no joints) ablation-resistant parts capable of withstanding extreme high temperatures for periods of 60-90 seconds.

Extra-long spinning-grade asbestos fiber provides the unusual physical stamina in parts made from R/M Pyrotex felts. High strength-to-weight ratio and excellent percentage reten tion of physical properties afte exposure to high temperatures ar additional advantages of suc parts.

R/M Pyrotex felts are easy t handle. Readily available fro coaters or from R/M. Write fo complete information.

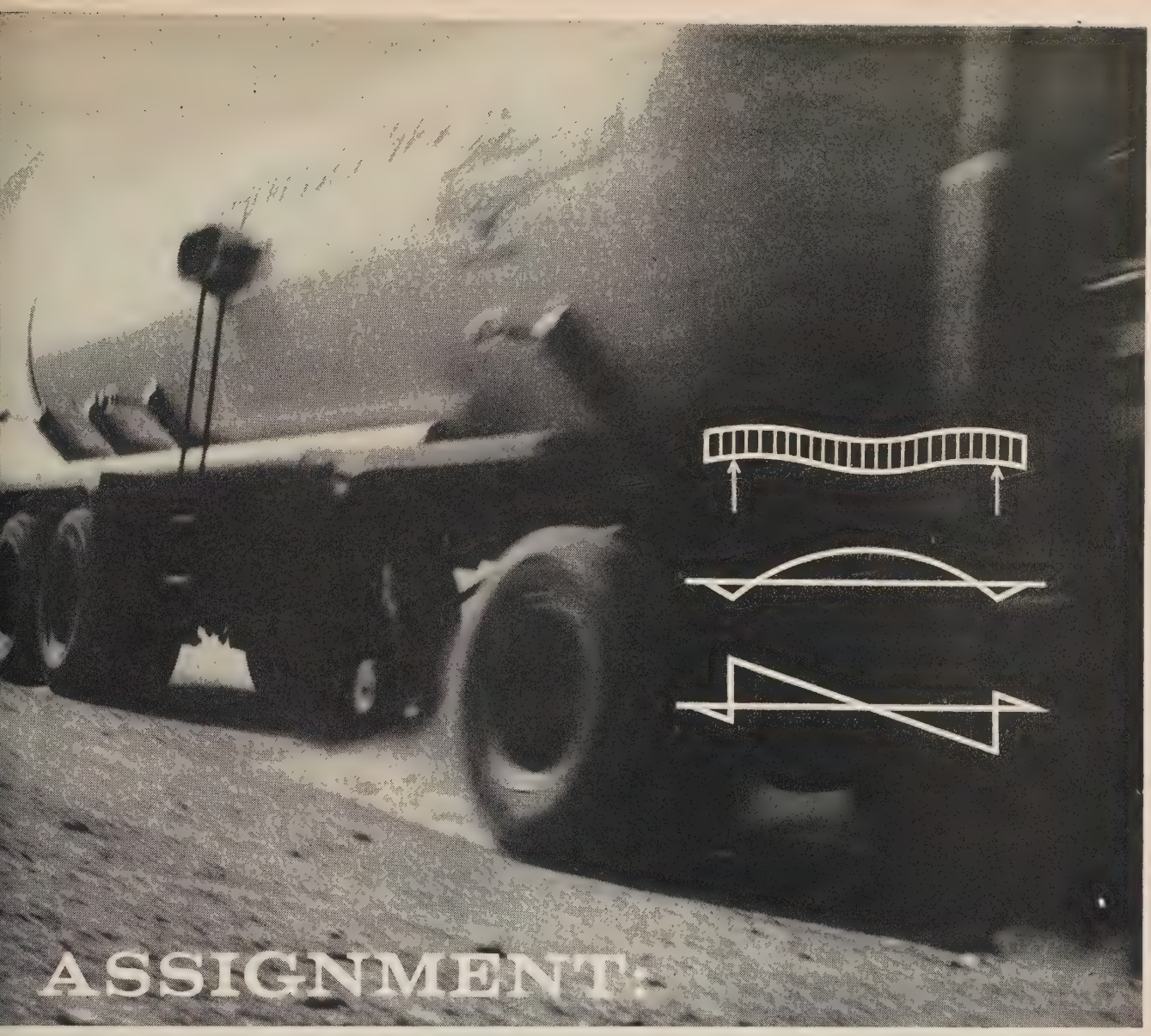
RM

RAYBESTOS-MANHATTAN, INC

Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED META

Write in No. 204 on Reader Service Card at start of Product Preview Section



STRENGTH/WEIGHT

How Lukens *Application Research* can help you find the right steel plate for the job

Designing for maximum payload means taking maximum advantage of today's high strength steels. Experts who know these steels—from a practical as well as technical standpoint—can give invaluable assistance in the early planning stages. This is the job of our Application Engineering staff.

LPG transport tanks and power shovels are widely divergent areas in which Lukens engineers have helped increase payloads.

The use of Lukens "T-1" steel plate and heads in tanks for hauling LP-Gas has fostered an entirely new design concept in the tank truck field. This high tensile, high yield strength steel (100,000 psi) makes it possible to mount wheels *directly on the tank.* The dead weight of heavy underframes goes into payload.

Working with a major producer of power shovels, our staff suggested tough Lukens "T-1" for buckets, dipper sticks, bucket teeth and other key parts. Lightweight, welded steel plate—rather than heavy castings—added as much as 40% to load capacity.

From these successful projects—and many more—our Application Engineers have gained knowledge and experience of value to design engineers. That's why we say... *if your assignment is strength/weight, let it be our assignment, too.* Contact Manager, Application Engineering, K-30, Services Building, Lukens Steel Company, Coatesville, Pa.

Helping Industry Choose Steels That Fit The Job

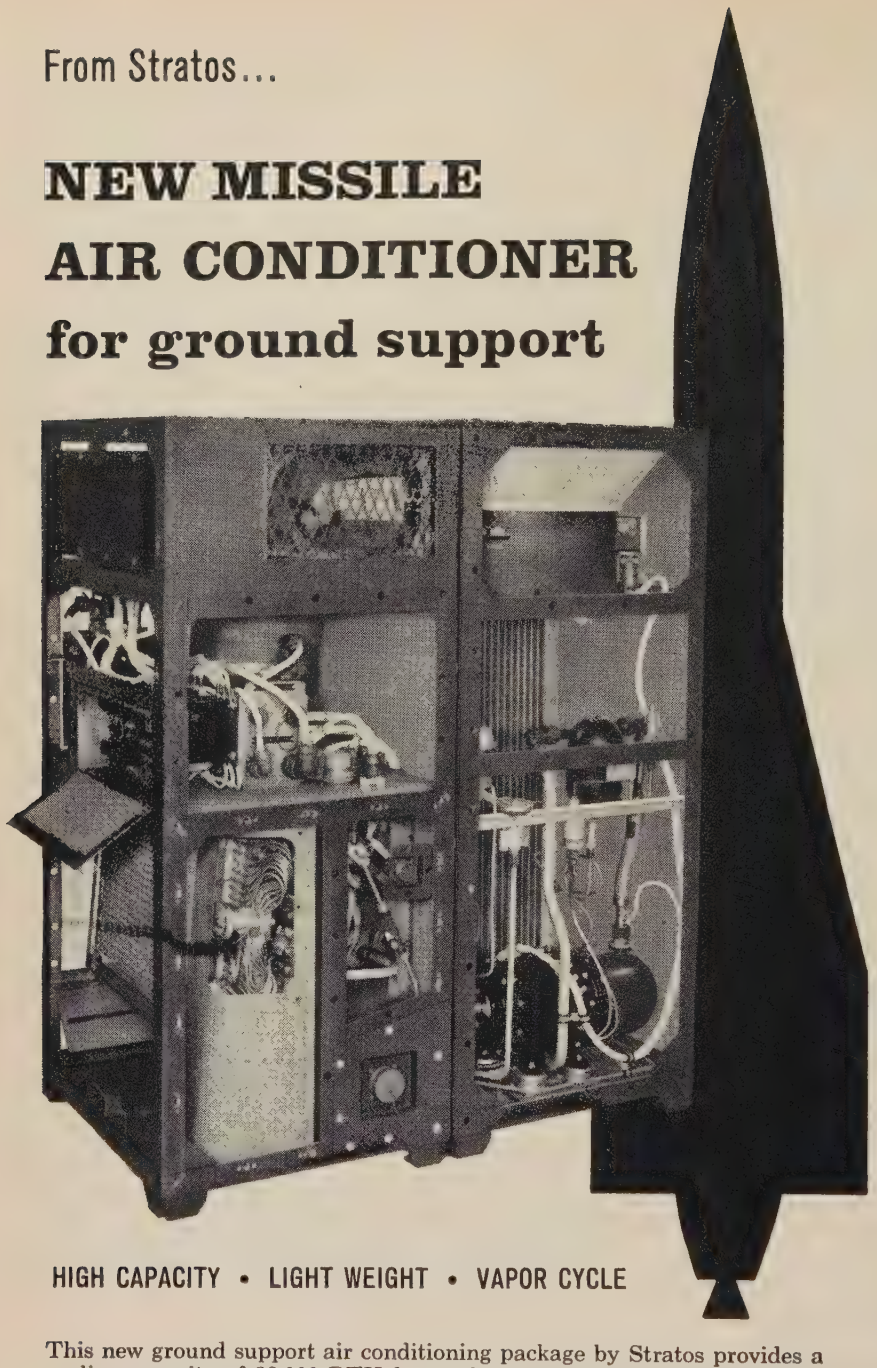
LUKENS ®

ASK FOR THE LUKENS "T-1" STEEL BULLETIN

Write in No. 205 on Reader Service Card at start of Product Preview Section

From Stratos...

NEW MISSILE AIR CONDITIONER for ground support



HIGH CAPACITY • LIGHT WEIGHT • VAPOR CYCLE

This new ground support air conditioning package by Stratos provides a cooling capacity of 38,000 BTU/hour when equipped with an 8-hp 7,550 rpm motor compressor unit . . . and 50,000 BTU/hour with a 13 hp 11,500 rpm unit. Weighing only 350 pounds complete, measuring just 40" x 24" x 49", and rated at 3.2 or 4.2 tons, the Model VEA4-3 air conditioner amply demonstrates the high capacity that can be achieved in a compact package – due to Stratos' unique Heli-Rotor compressor and efficient evaporators and condensers. The rugged VEA4-3 unit meets military specifications.

Specifications:

Conditioned air flow	80-90 lb/min.
Output Temperature	Automatically controlled 60° to 90° F ±2°
Weight	350 pounds complete with cabinets, charge and controls
Heating Capacity	37,000 BTU/hr. (11 kw)
Electrical System	208 or 416 V, 3 phase, 400 cycle, 4 wire
Cooling Capacity	38,000 or 50,000 BTU/hr.
Controls	Remote panel, cable connected
Refrigerant	Refrigerant 12

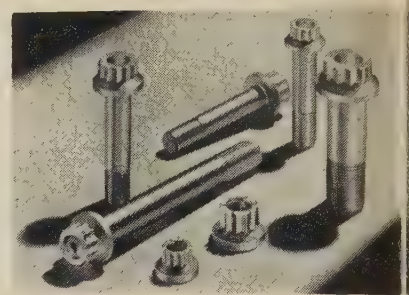
STRATOS

A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

Bay Shore, L. I., N. Y.

Write in No. 206 on Reader Service Card at start of Product Preview Section

FASTENERS are very strong

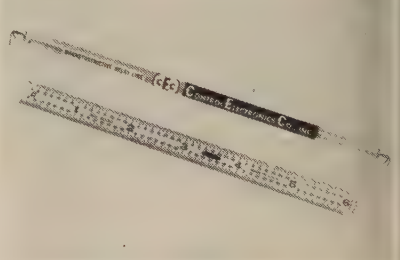


Threaded joints on these steel bolts and self-locking nuts have increased the strength ceiling of aircraft and missile fasteners, says **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** Minimum tensile strength is rated at 260,000 psi, and a single 1¼-in. diameter bolt could support a load of 146 tons.

The threads have been rolled onto the bolts at a Rockwell C-scale hardness of 51 minimum. The Series EWB 26 wrenching bolts and companion FN 26 Series nuts are said to be industry's strongest standard threaded joints. Yield strength is 215,000 psi, shear strength is 156,000 psi, and fatigue strength, at 65,000 cycles, is 135,000 psi. The fasteners are now being made in diameter sizes #10 through 1¼ in.

Write in No. 318 on Reader Service Card

DELAY LINES withstand high shock



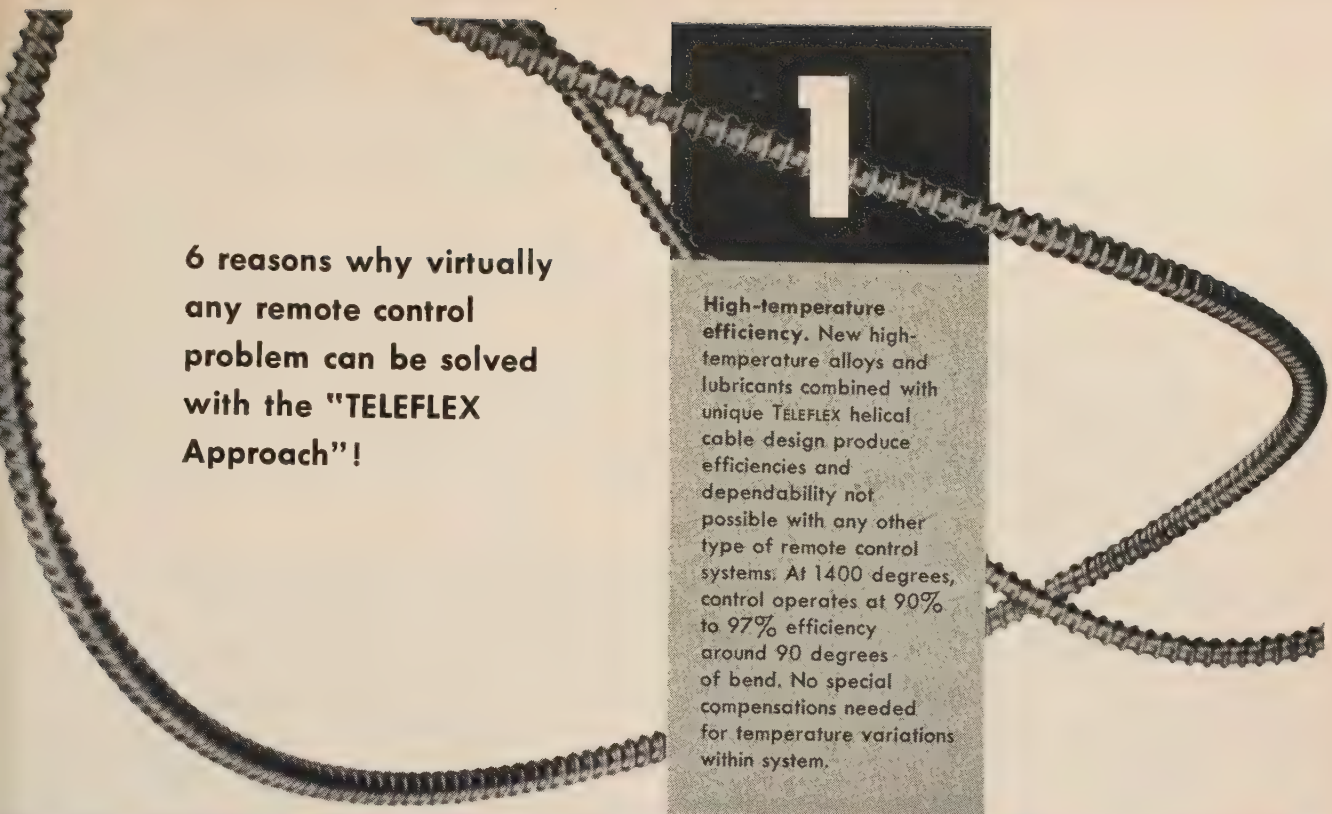
This series of solid state magnetostrictive delay lines, with short delays available from 5 to 200 micro sec, easily withstands vibration to 500 cps at 15 G and shock to 50 G. In addition to long life, these delay lines have extreme temperature stability and operate from −55 deg C to ±100 deg C with a coefficient of less than 20 PPM per deg C, says **Control Electronics Company, Inc., Dept. S/A, 10 Stepar Pl., Huntington Station, N.Y.**

The delay lines have a range of input-output impedances from 5 to 200 ohms with carrier or pulse frequencies up to 1 mc. The lines have an insertion loss of 54 db and taps can be supplied and spaced as close as 3 micro sec with or without an adjustment feature.

Write in No. 319 on Reader Service Card

more on page 264

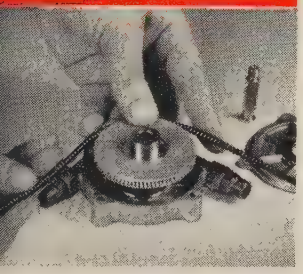
6 reasons why virtually any remote control problem can be solved with the "TELEFLEX Approach"!



1

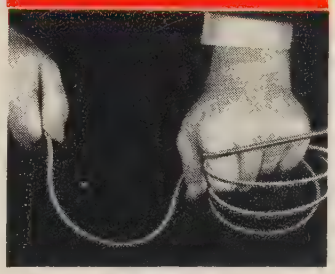
High-temperature efficiency. New high-temperature alloys and lubricants combined with unique TELEFLEX helical cable design produce efficiencies and dependability not possible with any other type of remote control systems. At 1400 degrees, control operates at 90% to 97% efficiency around 90 degrees of bend. No special compensations needed for temperature variations within system.

2



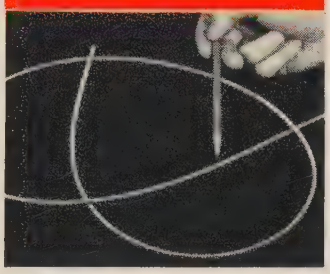
curate drive. Helical design TELEFLEX cable engages with pecially hobbed wheel for itive drive in tension and npression. Result: unlimited ft rotation in either ection—exclusively h TELEFLEX Systems !

3



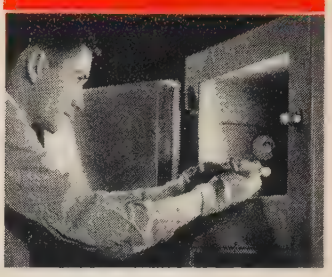
Flexible installation. TELEFLEX Systems can be designed over, around, under obstructions without loss of extreme accuracy. Cable can be operated at 100 feet or more with minimum change in load characteristics.

4



Minimum space. TELEFLEX Systems weigh 54% to 60% less than comparable cable pulley, or rod and bell cranks; take only 1/9 as much space. No interference or leeway problem in your intricate units. Design into space that's left.

5



Expert design. TELEFLEX engineers are specialists in remote controls ! Backed by an extensive research and development department, they can help you get around any remote control problem, no matter how advanced.

6

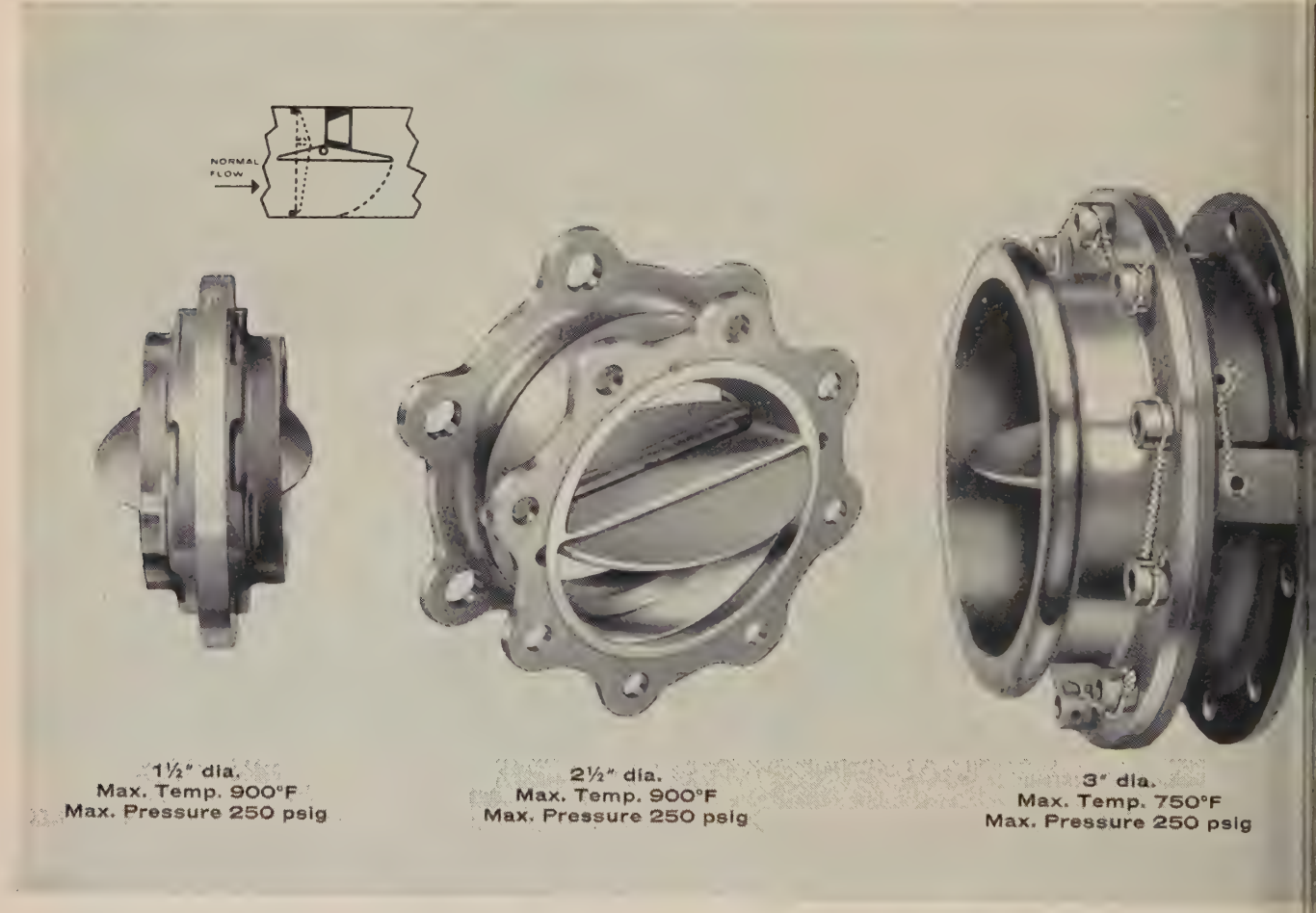
The record behind the "TELEFLEX Approach." Because there is no other cable like TELEFLEX, our engineers go beyond the point where all other systems come to a design stop—bring a new concept in the development and appreciation of remote control systems. Let us pit the "TELEFLEX Approach" against the problem you're working on now. Send for information today.

TELEFLEX® Incorporated, North Wales, Pennsylvania

Write in No. 207 on Reader Service Card at start of Product Preview Section

which of these lightweight check valves by Barber-Colman best meet the needs of your aircraft and missile applications?

On your next design problem involving air check valves, you may very likely have a ready answer with a Barber-Colman valve — either in standard sizes or special sizes and adaptations developed to fit your own requirements. Wide selection of precision butterfly . . . split flapper . . . single flapper . . . and inline types for various applications, as illustrated.



1½" dia.
Max. Temp. 900°F
Max. Pressure 250 psig

2½" dia.
Max. Temp. 900°F
Max. Pressure 250 psig

3" dia.
Max. Temp. 750°F
Max. Pressure 250 psig

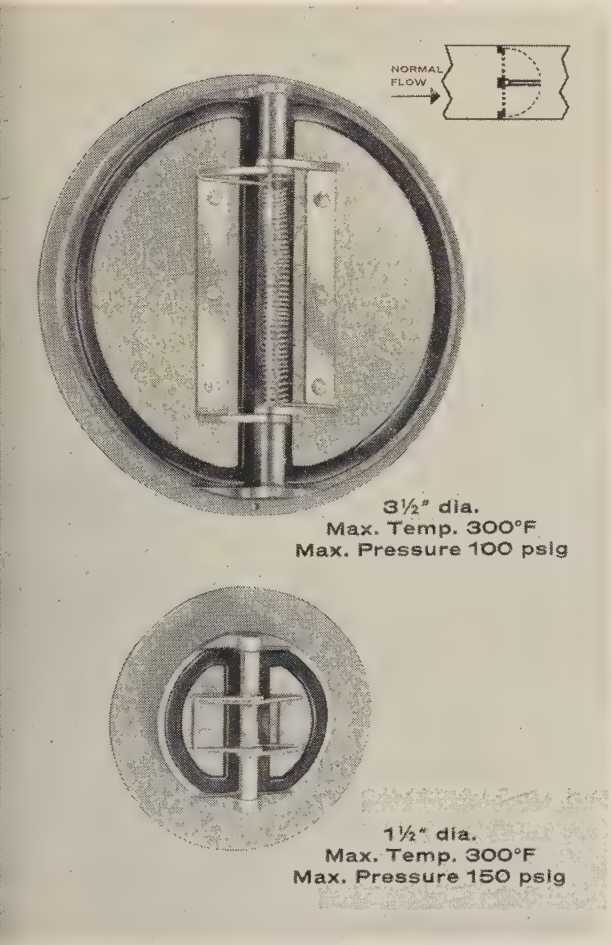
PRECISION BUTTERFLY...STAINLESS STEEL

Combining ruggedness and light weight, these Barber-Colman precision pneumatic check valves provide positive checking of rapidly reversing high-temperature, high-pressure air surges. Typical applications include use of these valves in jet engine starting systems, compressor bleed air systems for checking flow in event of engine stoppage, and controlling air flow into a wing thermal anti-icing manifold. These valves pass 10G vibration and feature extremely low leakage, low pressure drop. For a typical 2½" unit, total leakage does not exceed 0.1 lb per minute for any combination of air temperature from 80°F to 900°F and pressure from 5 psig to 250 psig. For most combinations, leakage is less. In addition to the 1½", 2½", and 3" sizes shown, others can be designed for you.

Write in No. 208 on Reader Service Card at start of Product Preview Section

SPLIT FLAPPER

arber-Colman split flapper type check valves are signed for a wide range of air applications em- oying lower temperatures and pressures. Models ustrated below are constructed of aluminum, but me general design can be produced in stainless eel for higher temperature, higher pressure appli- tions. Standard sizes are 1½", 2", and 3½". her sizes can be designed to your requirements. ompact, lightweight. 1½" size weighs .12 lb, 3½" e weighs .21 lb. Maximum internal leakage 1½" e: .04 lb/min . . . 3½" size, 0.1 lb/min.

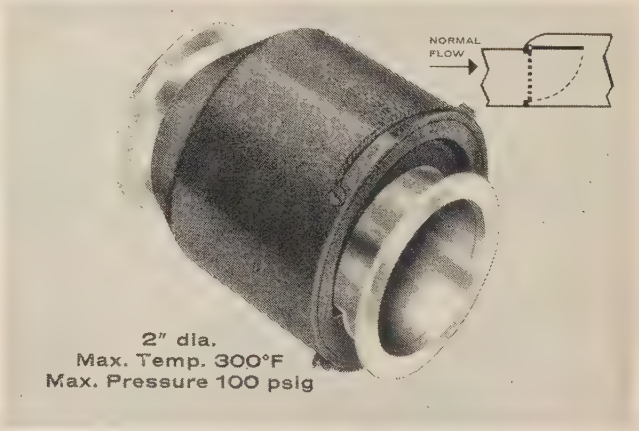


3½" dia.
Max. Temp. 300°F
Max. Pressure 100 psig

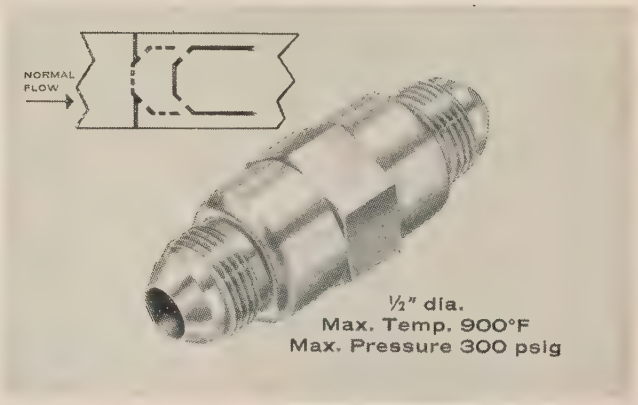
1½" dia.
Max. Temp. 300°F
Max. Pressure 150 psig

SINGLE FLAPPER

An economical aluminum check valve designed for low pressure applications. Typical use is checking air conditioning system ram air. Weight .75 lb. Maximum leakage .04 lb/min at 100 psig, 300°F.



2" dia.
Max. Temp. 300°F
Max. Pressure 100 psig



½" dia.
Max. Temp. 900°F
Max. Pressure 300 psig

INLINE

Barber-Colman inline check valves are designed for ¼" and ½" O.D. tubing. Simple, foolproof operation, for use in servo line and similar applications. Weight, ½" size, .26 lb. Minimum internal leakage .05 lb/min.

THER HIGH-QUALITY, LIGHTWEIGHT BARBER-COLMAN VALVES

otor-operated butterfly . . . poppet . . . sliding port . . . and drain valves are also available from Barber-Colman Company in dition to check valves described here. Write for helpful data sheets on the type valve you need, or consult the Barber-Colman gineering sales office nearest you: Baltimore, Boston, Fort Worth, Los Angeles, Montreal, New York, Rockford, Seattle.

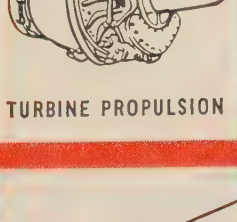
THE MARK OF QUALITY

BARBER COLMAN

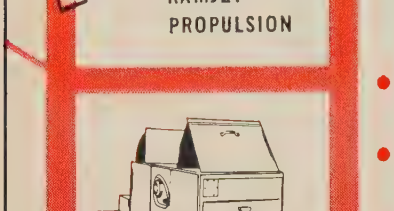
BARBER-COLMAN COMPANY

DEPT. C, 1423 ROCK STREET, ROCKFORD, ILLINOIS

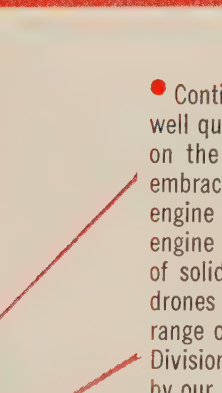
AIRCRAFT AND MISSILE PRODUCTS: AIR VALVES, ELECTROMECHANICAL ACTUATORS, TEMPERATURE CONTROL AND POSITIONING SYSTEMS, TRANSDUCERS AND THERMOSTATS, SPECIAL GROUND TEST EQUIPMENT



TURBINE PROPULSION



SOLID FUEL—
RAMJET
PROPULSION



GROUND SUPPORT

CAE POWER

- Research
- Development
- Production

Continental Aviation & Engineering Corp. is exceptionally well qualified, both by experience and by facilities, for work on the weapons systems of tomorrow. Our background embraces not only a half-century of internal combustion engine experience, but also years of pioneering in gas turbine engine development, and more than a decade in the field of solid fuels for ramjet propulsion of missiles and target drones . . . Continental is staffed and equipped for a wide range of assignments, military and commercial. The Detroit Division Research and Development Department is supported by our modern-to-the-minute Component Testing Laboratory complete with environmental facilities located at Toledo. The Toledo Production Division now producing various turbine engines in volume is capable of supporting diversified programs . . . The CAE record of achievement is one of which many a larger company might be proud. Inquiries are invited from those having propulsion problems, on the ground, on the water, in the air.

CONTINENTAL AVIATION

CONTINENTAL AVIATION & ENGINEERING CORPORATION

GENERAL OFFICES AND RESEARCH AND DEVELOPMENT DEPARTMENTS AT 12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN . . . PRODUCTION DIVISION AND FIELD SUPPORT, 1330 LASKEY ROAD, TOLEDO, OHIO.

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

Write in No. 209 on Reader Service Card at start of Product Preview Section

AIRSPEED COMPUTER has miniature design

Minitas, a miniature true airspeed computer, has been made available in three operating ranges and accuracies to extend its usefulness to high speed aircraft, patrol planes, helicopters, artillery-directing aircraft, and missiles, according to **Servomechanisms, Inc., Dept. S/A, 12500 Aviation Blvd., Hawthorne, Calif.** Components of the 6.5-lb device include a very sensitive and accurate force balance Mach transducer, a passive-resistance network, and a follow-up servo, and the unit measures five in. in diameter by 8¼ in.

Top range of the AXC 620 Series is 300 to 1500 k over a zero to 80,000-ft. altitude span. Standard accuracy under these conditions is ±12 deg K.

Write in No. 320 on Reader Service Card

JIG MILLS have simple dimensioning

This direct dial dimensioning system for DeVlieg Spiramatic jig mills is said to be a simplified, accurate means of pre-setting dimensions for automatic point-to-point positioning. "Diatrol" eliminates measuring rods and allows direct dialing of positive or negative dimensions from any arbitrarily selected datum plane within the range of the control system, says **DeVlieg Machine Co., Dept. S/A, Fair St., Royal Oak, Mich.**

It is stated that absolute measuring accuracies, well within the tolerance range of the jig mill, may be selected repeatedly. Positioning and control elements are said to be completely protected to insure continuous performance.

Write in No. 321 on Reader Service Card

more on page 26

from Sundstrand . . .

a major advance in turbine engine starter design

ndstrand's new combination jet engine rter offers advancements of singular portance to using commands con- ned with the alert mission concept and ondary airbase mobility.

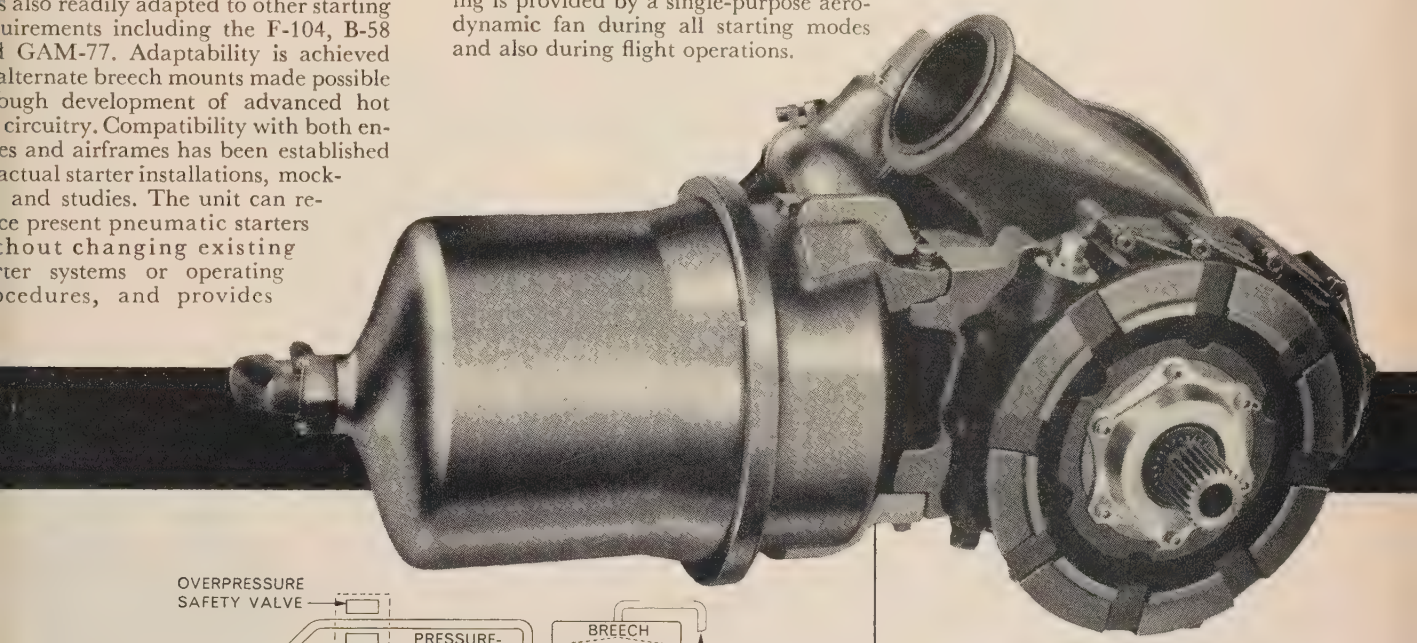
FETY: In each starting mode—car- lge, high-pressure bleed air, and low- ssure ground cart air—nine fail-safe tures protect personnel, aircraft and rter against multiple cascade failures e Figs. 1 and 2).

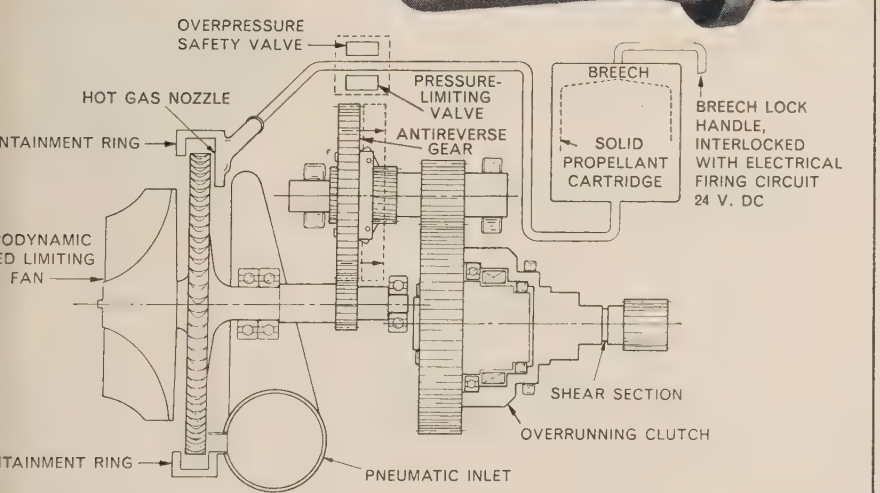
RSATILITY: The basic starter is npletely interchangeable for the F-100, 01, F-105, B-52 series, and the KC-135. s also readily adapted to other starting uirements including the F-104, B-58 d GAM-77. Adaptability is achieved alternate breech mounts made possible ough development of advanced hot circuitry. Compatibility with both en- es and airframes has been established actual starter installations, mock- and studies. The unit can re- ce present pneumatic starters thout changing existing rter systems or operating ocedures, and provides parallel, self-contained cartridge mode.

STATE-OF-THE-ART ADVANCES: Pressure-limiting valve controls cartridge burn rate to obtain desired combination of starting torques and times—provides consistent starting torques from —65°F to +160°F—controls burn pressure during start to compensate for erratic cartridges. Overpressure safety valve can be 100% inspected and is resettable to eliminate nuisance removals. Integral throttling duct controls pressure ratio across turbine—pressure regulating valve not needed for pneumatic starts. Speed limiting is provided by a single-purpose aerodynamic fan during all starting modes and also during flight operations.

LIGHT WEIGHT: Sundstrand engineers have designed the new starter into a compact, lightweight module that weighs less than 60 pounds.

The Sundstrand cartridge/pneumatic starter has firmly established its capability through actual engine starting tests on the basic J-57 series at Air Force installations, and is the first unit to successfully start the ducted fan version for the B-52H. Based on analysis of starting torques and times requirements, the basic starter is also adaptable to the J-52, J-75, and J-79 engines.





1—Schematic drawing of Sundstrand cartridge/pneumatic jet engine starter. Illustration shows le, compact spur gear, single jackshaft gear reduction, movable breech, and nine components of ade fail-safe design.

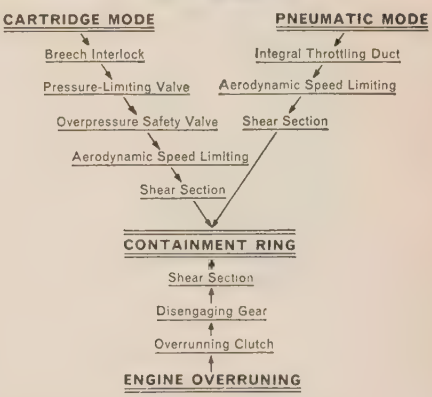


Fig. 2—Outline showing sequence of cascading safety features. Nine fail-safe systems provide optimum protection for personnel, aircraft, and starter.

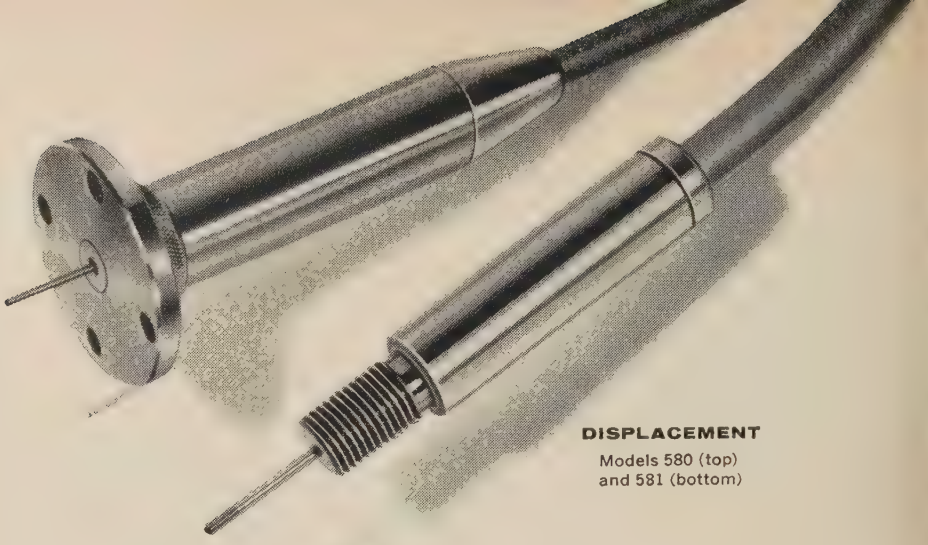
SUNDSTRAND

SUNDSTRAND AVIATION

VISION OF SUNDSTRAND CORPORATION
ROCKFORD, ILLINOIS

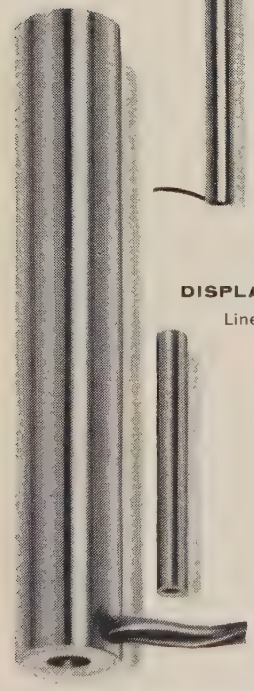
District Offices: Arlington, Texas; Hawthorne, California; Rockford, Illinois; Dayton, Ohio; Seattle, Washington: Stamford, Connecticut; Washington, D.C.

Write in No. 210 on Reader Service Card at start of Product Preview Section



DISPLACEMENT
Models 580 (top)
and 581 (bottom)

VELOCITY
LVsyn

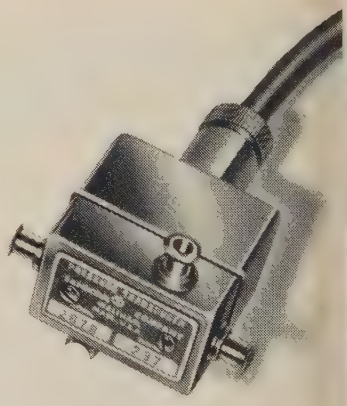


DISPLACEMENT
Linearsyn

Precision Transducers FROM SANBORN

Linear motion transducers available from Sanborn Company now include the compact, ready-to-use flange-mounted *Model 580* and threaded *581* "probe-styles" for displacements as small as 0.00002″ . . . thirty models (shielded and unshielded) of the rugged *Linearsyn* differential transformer for strokes from ±0.005″ to ±1.0″, displacements as small as 0.000001″ . . . and twelve models of the *LVsyn* for producing a DC voltage proportional to a linear velocity. Features of the *580—581* probe-style units include 0.5% linearity; basic sensitivity at 2400 cps of 2.4 volts output / inch displacement / volt excitation; built-in output level adjustment, phase shift and temperature change compensation; carbide-tipped stainless steel contact rod riding in jeweled bearings. Both the *LVsyn* and *Linearsyn* transducers are extremely durable units, immersible in working fluids, introduce little or no friction, and have infinite resolution. Standard Linearsyn coil lengths range from 0.564″ to 6.88″, LVsyn coil lengths from 3.16″ to 22.75″.

For differential and single-ended pressure measurements, *Series 267 and 268* transducers for operation in a carrier system offer sensitivities of 40 uv/mm Hg / volt excitation and 40 uv / 0.1 mm Hg / volt excitation. Compact, Monel cases have standard Luer connectors.



PRESSURE
Series 267, 268

Contact your local Sanborn Sales-Engineering Representative for bulletins containing complete facts or write the Sanborn Industrial Division in Waltham. Sanborn Sales-Engineering Representatives are located in principal cities throughout the U. S., Canada and foreign countries.

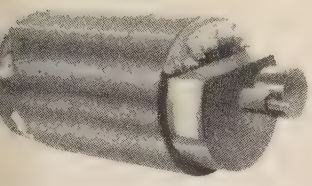
for long stroke, high pressure, high temperature requirements . . .

. . . special-order LVsyn and Linearsyn displacement transducers can be supplied. Strokes up to 20″ are possible . . . pressure ratings up to 5000 psi, when transducer is submerged in a high pressure medium . . . operating temperature ranges as wide as −65°F to +450°F. Consult factory, stating your requirements.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Mass.

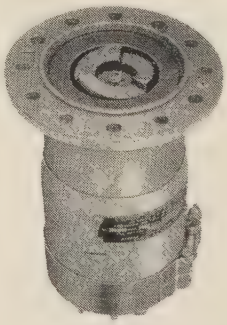
"At I.R.E. Show Booths 3601-03-05"

Write in No. 211 on Reader Service Card at start of Product Preview Section



VG-900
Starter-Generator
30 volts 200 amps
8000/12000 rpm
27.5 lbs.

VG-600
Starter-Generator
30 volts 100 amps
4700/8100 rpm
33 lbs.



BW-125
Direct-Cranking Starter
28 volts DC
11 h.p.
20.5 lbs.

VG-700
Starter-Generator
30 volts 200 amps
4400/8100 rpm
38.5 lbs.

VG-840
Starter-Generator
30 volts 100 amps
8000/12000 rpm
15 lbs.

Application Engineered Starters and Starter Generators Designed for Gas Turbine Systems

Talk to Breeze when you require standard or custom starters or starter generators for your gas turbine system. Breeze is well-experienced in the design and production of compact, lightweight blast-cooled and fan-cooled units up to 200 amp capacities.

Breeze engineers will work closely with you while your gas turbine system is being developed to make certain your requirements are met satisfactorily. Then, depending upon the characteristics of the system Breeze will adapt a field-proven unit or develop an entirely new design for your application.

Produced in large or small production runs, all Breeze standard or custom starter and starter generators are built to meet military specifications.

You'll want a copy of Catalog 88 SG which includes design information on Breeze Starters and Starter Generators. If you have a specific requirement, write describing the details and let Breeze Application Engineers work along with you.

BREEZE MARK

BREEZE CORPORATIONS, INC.

700 Liberty Avenue, Union, New Jersey • Telephone: MUrdock 6-4000

Manufacturers of electrical, electro-mechanical and hydro-mechanical components and systems and fabricated metal products.

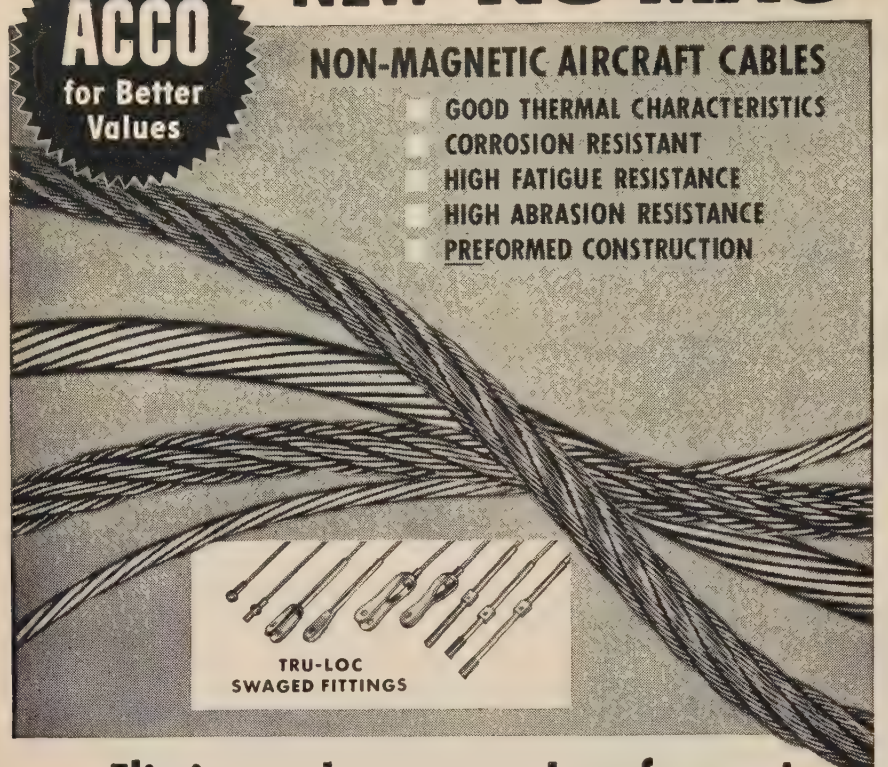
Write in No. 212 on Reader Service Card at start of Product Preview Section

NEW "NO-MAG"

ACCO for Better Values

NON-MAGNETIC AIRCRAFT CABLES

- GOOD THERMAL CHARACTERISTICS
- CORROSION RESISTANT
- HIGH FATIGUE RESISTANCE
- HIGH ABRASION RESISTANCE
- PREFORMED CONSTRUCTION



Eliminates Instrument Interference!

• Just as we expected, many aircraft designers were interested in the recent announcement of our new non-magnetic aircraft cable. If you did not see it, "NO-MAG" has these characteristics:

NON-MAGNETIC PROPERTIES . . . "NO-MAG" cable is made from type 305 stainless steel. It remains non-magnetic after severe cold working —in contrast to standard stainless steel aircraft cable which shows a pronounced increase in magnetism after swaging, wire drawing or similar operations.

This non-magnetic property of "NO-MAG" cable eliminates instrument interference from cable magnetism.

CORROSION RESISTANCE . . . New "NO-MAG" cables have corrosion-resistant qualities similar to, but slightly better than, cables made of standard stainless steel.

GOOD THERMAL CHARACTERISTICS... The thermal expansion characteristics of new "NO-MAG" cable are much closer than those of standard stainless steel or carbon steel cables to the characteristics of aluminum alloys used in aircraft. This greatly simplifies maintaining cable tension under various changes in temperature.

HIGH FATIGUE RESISTANCE . . . Preformed construction and careful processing give new "NO-MAG" cable high fatigue resistance.

HIGH ABRASION RESISTANCE . . New "NO-MAG" cable shows greater abrasion resistance than standard stainless steel aircraft cables.

TENSILE STRENGTH, while lower than that of stainless and carbon steel, is sufficient to enable replacing these, size for size, with "NO-MAG" on many applications where the characteristics of "NO-MAG" are required.

USE WITH SWAGED TERMINALS . . . Swaged terminals can be applied to standard AN dimensions.

COMPLETE RANGE OF SIZES, CONSTRUCTIONS . . . New "NO-MAG" is furnished in sizes from 1/16" to 1" in all of the standard aircraft cable constructions.

Get the complete story on this new technical development for the aircraft industry. Write today to Detroit office.

Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

ACCO TRADE MARK

601 Stephenson Bldg., Detroit 2

6800 East Acco Street, Los Angeles 22 • Bridgeport 2, Conn.

Write in No. 213 on Reader Service Card at start of Product Preview Section

AC-DC GENERATOR weighs 53 lbs

This multi-output ac/dc generator combines two windings for a respective ac and rectified dc output in the stator of any conventional generator. Integrating the rectification elements and their protection within the bulk of the generator is said to eliminate need for separate transformer-rectifier and its installation and cooling problem, says **American Machine & Foundry Co., Leland Airborne Div., Dept. S/A, Vandalia, Ohio.** It weighs 53 lb.

The generator is said to have demonstrated improvement in overall losses, protection of rectification elements, and reduced radio noise.

Write in No. 322 on Reader Service Card

MINIATURE MOTOR is open-frame type

This type 820 permanent-magnet dc motor uses a magnet design to achieve high starting torque at operating speeds upwards of 20,000 rpm, in a unit weighing 1.4 oz. It is available on any specified dc voltage between 3 and 30 V, with armatures wound to produce any desired no-load speed between 5000 and 30,000 rpm at the specified input voltage, says **Cramer Controls Corp., Dept. S/A, Centerbrook, Conn.** Locked-rotor (max) torque is approximately 0.5 inch-oz, with working torques in the range of 0.4 to 0.1 inch-oz between output speeds of 5000 and 20,000 rpm.

With constant load, speed is said to be almost a linear function of applied voltage.

Write in No. 323 on Reader Service Card

CERAMIC CAPACITORS for high temperatures

Miniature size and reliability are features of the VK ceramic capacitor that is designed to operate from −55 to +150 deg C at 200 V dc without derating, says **Vitramon, Inc., Dept. S/A, Box 544, Bridgeport 1, Conn.** Capacitance ranges from 47 to 10,000 mmf.

Improvements in the ceramic formula and in electrode stacking techniques have overcome peripheral short circuiting across the electrodes under surge voltage. The VK units will withstand a potential of 800 V dc applied for ten sec at 25 deg C. Capacitance change over the temperature range is typically plus or minus ten per cent, with a ±15 per cent maximum excursion. VK20W measures 0.2 in. sq. by 0.1 in. thick and capacities extend through 1000 mmf. VK30W measures .3 in. sq. by 0.1 in. thick and values extend through 10,000 mmf.

Write in No. 324 on Reader Service Card

more on page 270

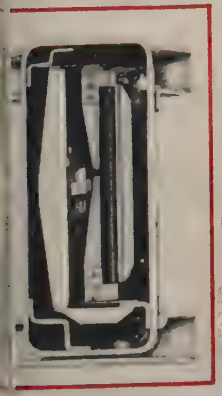
Write in No. 214 on Reader Service Card

The most precise, sturdiest thermal relay ever built... best for missile applications

. . from the leader in thermal relay design!

w, for missile environments and for all applications where greater precision is necessary, G-V Controls ers the revolutionary new PT Thermal Relay—the most **precise** thermal relay ever built!

d the PT's **sturdiness** is unequalled in thermal relays. It withstands missile vibration and shock far ter than any other thermal relay.



SPECIFICATIONS

Time Delay: 3 to 60 seconds (Factory Set)
Setting Tolerance: ±5% (±¼ sec. min.)
Temperature Compensation: Within ±5% over −65°C. to +125°C. range (±¼ sec. min.)
Heater Voltages: 6.3 to 115 v. for delays up to 12 sec.; 6.3 to 230 v. for longer delays.
Power Input: 4 watts. Rated for continuous energization at 125°C.
Contacts: SPST, normally open or normally closed. Rated 2 amps. resistive at 115 v. AC or 28 v. DC.

Write for Product Data Bulletin #PD-1015

Insulation Resistance: 1,000 megohms
Dielectric Strength: 1000 v. RMS at sea level. 500 v. RMS at 70,000 ft.
Vibration: Operating or non-operating, 20 g up to 2000 cps
Shock: Operating or non-operating, 50 g for 11 milliseconds
Unidirectional Acceleration: 10 g in any direction changes delay by less than 5%, 50 g by less than 10% with proper orientation.
Weight: 2 to 2¼ ounces.

G-V CONTROLS INC.
Livingston, New Jersey

G-V®

IDEAL AEROSMITH

sets the pace in the development of PRECISION NEEDLE VALVES

Ideal Aerosmith is the leader in the designing and building of Precision valves for critical control or metering of liquids or gases.

LOOK FOR THESE FEATURES:

- Micrometer type vernier scales available on most sizes and models for consistent repeatability.
- Exclusive IDEAL design: Precise control is assured by the slim taper of the needle. Twenty turns for full open.
- Available in Bronze or 18-8 stainless steel.
- Available in ⅛" to ½" pipe size.
- Teflon seating available. Special valves built on request.

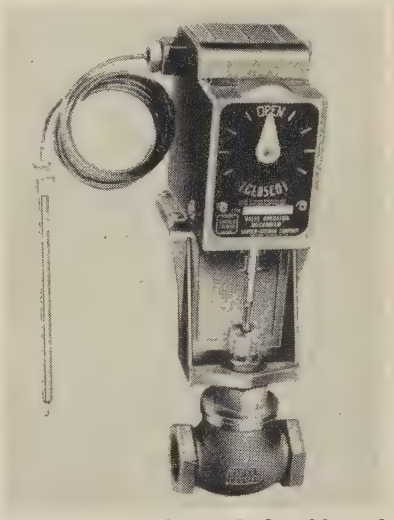
Some choice distributorships are still available

IDEAL AEROSMITH
A Subsidiary of Royal Industries
CHEYENNE, WYOMING

Write in No. 215 on Reader Service Card

REGULATOR is self-contained

This temperature regulator for proportional control of water, gas, or low pressure steam features a self-contained valve assembly that offers tight closing and rugged construction, says **Barber-Colman Co., Dept. S/A, 1300 Rock St., Rockford, Ill.** The regulator has a clearly marked calibrated adjusting dial for precise temperature control, an electric industrial motor operator, and armored capillary tube.



There are no adjustments necessary, save for the setting of the control dial to the desired temperature. Applications include air conditioning units, plating tank control, and industrial process control.

Write in No. 325 on Reader Service Card

TAPE RECORDER has 20-kc FM response

Special head design and advanced electronics of the FR-600 analog magnetic tape recorder permit FM response from dc to 20 kc, within ½ db, and direct recording to 250 kc, says **Ampex Corp., Dept. S/A, 934 Charter St., Redwood City, Calif.** Solid state electronics are used throughout the recorder, which can provide FM, pulse duration modulation, direct or digital recording models by means of plug-in amplifier modules.

The FR-600 is designed with an air-lubricated tape guiding system that eliminates physical contact between guide and tape. The result is lower friction, faster starts, less tape wear, and flutter that is reported to be lower than that of any other standard machine available. The unit accepts both 10½- and 14-in reels, and ½- and one-in tape.

Write in No. 326 on Reader Service Card

more on page 272

18,000 leading shops depend on Kroil when a frozen bearing, bushing or bolt threatens production or starts to cost expensive man hours.

During seventeen years they have learned that it pays to use Kroil first and save parts. In these days of high labor costs, shops cannot afford to use hammer-and-chisel methods when stuck-together parts cause trouble.

WHAT USERS SAY:

"As I remember, we had quite a bit of construction machinery lying around in our yard. Suddenly there was a rush call for some of it but 90% of the pulleys on this machinery was locked by rust. We then applied Kroil to each one and the next morning the machinery was ready to roll."

Try Kroil at our risk. Send for a gallon—use it under the worst conditions. Return it for full credit if not satisfied. Kroil, $4.35 a gallon; Kroiler, $1.50 each . . . together, $5.25, f.o.b. Nashville.

KANO LABORATORIES
1097 Thompson Lane,
Nashville 11, Tenn.

Write in No. 216 on Reader Service Card

CLOSURES

- Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.
- Protect against thread damage, dust, dirt, and moisture.
- For inside and outside application.
  All sizes. Immediate delivery.

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

METAL plugs for AN & SAE threads

PLASTIC tube cap for AN & SAE parts

Send coupon today!

Gentlemen: Please send samples and prices of closures in Polyethylene ☐ Aluminum ☐

Name.....

Address.....

City.....

CLOVER INDUSTRIES, INC. 602 Young Street Tonawanda, N. Y.

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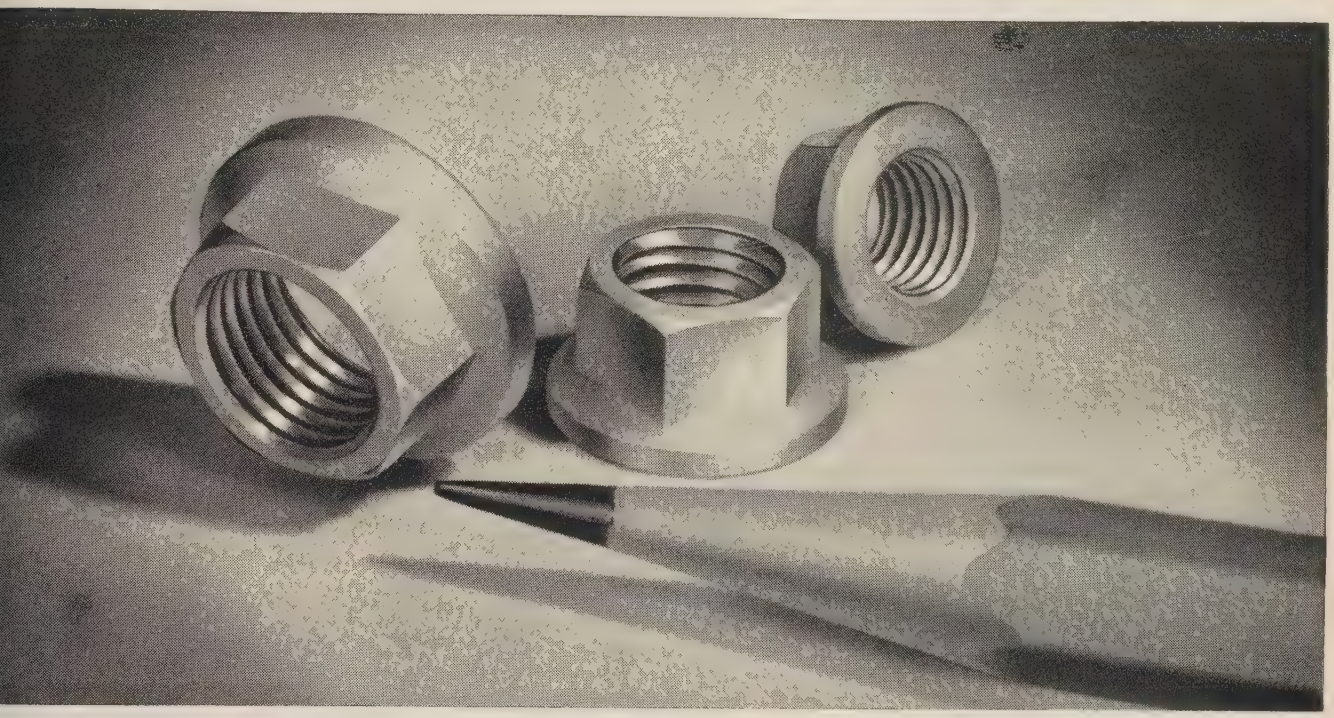
FIRST TO MEET **MS 21042** AND **NAS 1291**

SPS FN-12 Featherweight locknut replaces NAS 679 and equivalents*—saves up to 72% in locknut weight



SPS FN-12 Series Featherweight locknut was the first to meet new MS 21042 calling for a lighter weight replacement for NAS 679 sheet metal nuts. New forged featherweight offers major weight savings, superior performance, high reliability; also permits secondary weight reductions through use of narrower bolting flanges.

ere is the only nut series that meets the new MS 21042 andard, calling for a lighter weight locknut that can niversally replace the heavier-type AN 363, MS 20364, IS 20365 and MS 21040 Series.

The new SPS FN-12 weighs as much as 60% less than AS 679 sheet metal nuts and counterparts . . . up to 2% less than equivalent MS or AN types.*

The FN-12 saves weight in another way also. Because its new configuration, it can be installed closer to ertical bulkheads than any other aircraft nut now in se. This allows a narrower bolting flange, with consequent reductions in aircraft weight.

You can specify FN-12 Series Featherweight locknuts 7 sizes—#4 through ⅜". All sizes are available for mmediate delivery. From #4 to 5/16", FN-12 locknut ices are practically the same as NAS 679 locknuts. In e ⅜" size, the price is considerably lower.

For more information, write SPS—manufacturer of ecision threaded fasteners and allied products in many etals, including titanium. Request Bulletin 2426.

ACTUAL WEIGHTS OF FN-12 AND COMPARABLE LOCKNUTS

All Weights Expressed as Pounds per 1000 Pieces

Size	FN-12	NAS 679†	% Weight Saved by FN-12	AN Series‡	% Weight Saved by FN-12
#4-40	0.4	0.8-1.0	50%-60%	1.3	69%
#6-32	0.7	1.3-1.7	50%-60%	2.5	72%
#8-32	1.2	2.1-2.5	43%-52%	4.2	71%
#10-32	1.6	2.5-2.8	40%-47%	4.6	67%
¼-28	3.5	3.9-4.7	12%-26%	8.5	59%
5/16-24	5.4	6.4-7.2	16%-25%	11.8	54%
⅜-24	7.3	9.3	21%	19.5	63%

†Range of four most commonly used sheet metal nuts of NAS 679 type
‡Range for AN 363, 364, 365

*MS 20364, MS 20365, MS 21040; NAS 1021, NAS 1022; AN 363, AN 364, AN 365 and AN Plain Nuts

AIRCRAFT / MISSILE Division **SPS**

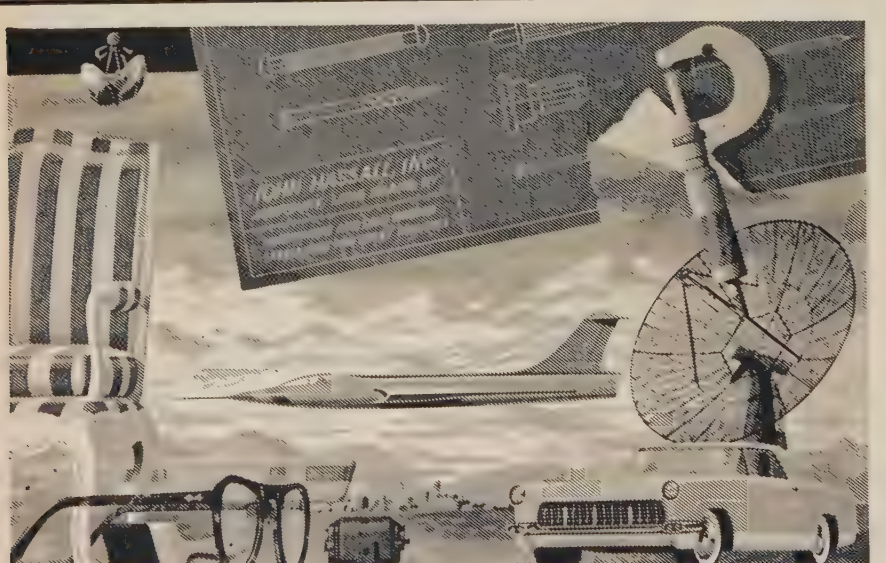
where reliability replaces probability

JENKINTOWN 54, PENNSYLVANIA
SPS WESTERN, SANTA ANA, CALIF.

Write in No. 218 on Reader Service Card at start of Product Preview Section

On Mark COUPLINGS
for ultimate reliability
MARTIN'S USAF TITAN ICBM
diversified launching systems are
to be fitted with ON MARK Vent Connector Couplings —
Developed by the ON MARK research and production team, this 6-inch coupling is fully qualified to Martin specifications.
If your group is seeking a solution to any coupling problem contact:
On Mark COUPLINGS, INC.
4440 York Boulevard, Los Angeles 41, California
Telephone: CLinton 4-2278
REPRESENTATIVES: AIRSUPPLY-AERO ENGINEERING
Division of the Garrett Corporation
Beverly Hills, Calif., Mineola, Long Island, N.Y.; Indianapolis, Ind.
The Garrett Corporation of Canada, Ltd., Montreal, Canada

Write in No. 219 on Reader Service Card at start of Product Preview Section



Job-Designed Fasteners for Every Industry

Hassall

Here is a fast, dependable, low cost, quality minded source of supply for JOB-DESIGNED fasteners of all types, in any metal, to fit your own assembly problem. Assembly costs are a very major part of manufacturing expense. Most of this is labor. The fastening medium itself is usually a minimum item. If a Job-Designed fastener makes assembly simpler and faster, permits the use of fewer fasteners, allows the designer functional freedom and improves product efficiency, yours is a specifying job well done. All these possibilities are available when you come to Hassall for design assistance and quotation on challenging, difficult or unusual rivets, threaded nails, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation for the concept of value analysis — all are part of the Hassall service to you.

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MANUFACTURERS SINCE 1850
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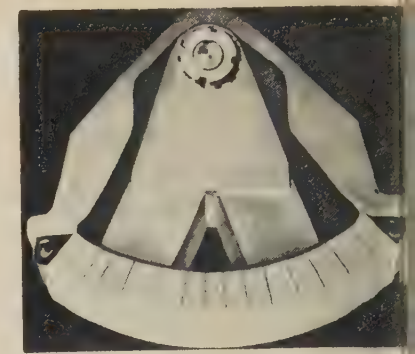
TORQUE MOTORS have high power ratio



Along with infinite resolution, th ARTQ dc torque motors, which hav been developed for use in high per formance airborne stable platforms inertial and tracking systems, an other applications, feature high ratio of torque to power and torque t weight, says **The Aeroflex Corp., Dept S/A, 34-06 Skillman Ave., Lon Island City 1, N.Y.** The low heat unit in this series have no commutator and thus eliminate brush replacement friction, radio noise, and explosio hazard.

A variety of torquer sizes up t 200 lb-in., various rotation limits u to 60 deg, and excellent torque versu input current linearity are als featured.

Write in No. 327 on Reader Service Car

PARAMETRIC DIOD for high-frequency cut-of

This new parametric diode ha been successfully tested in low-nois amplifiers used for extending th range of missile tracking and in over the-horizon communication equip ment, says **ITT Components Div International Telephone & Telegrap Corp., Dept. S/A, Clifton, N.J.** Cu off frequency ranges up to 150 km and zero bias capacitances are as lo as 0.4 mmf.

The diode also may be used i harmonic generators, frequency con verters, and voltage-tuned circuit Low capacitance is achieved b means of a very small diffused me junction and low series resistance attained through special control the diffusion process.

Write in No. 328 on Reader Service Ca

more on page 27

THE WORLD'S ONLY JET TO JET SERVICE

Between the U.S.A. and Europe, Africa and the Middle East!

Never before has any single airline come so close to fulfilling the ultimate promise of the "Jet Age." Now a traveler can speed overseas to Europe by Air France 707 Intercontinental Jet and, without changing airlines, continue throughout Europe, Africa and the Middle East by swift Caravelle Jet. This is truly the finest, fastest, most convenient service of its kind—Jet to Jet service on Air France.

Exclusive "firsts" like Air France Jet to Jet service don't just happen; they have to be planned. Early in 1957, Air France laid the groundwork for this unique service by becoming the first airline to test and operate Caravelles in Europe. Then, when the first Air France Boeing 707 Intercontinental Jet touched down at Orly Field, a fleet of pure jet Caravelles was ready to inaugurate Jet to Jet service!

It is just this quality of leadership in planning that has helped Air France become the world's largest airline.

AIR FRANCE JET

WORLD'S FASTEST JETLINER / WORLD'S LARGEST AIRLINE

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REPUBLIC VALVES
FOR EVERY INDUSTRY

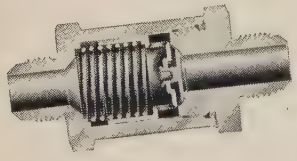
CHECKS

THAT FILL YOUR NEEDS

MINIATURE CHECKS

Mini-Valve — Regular Size Valve

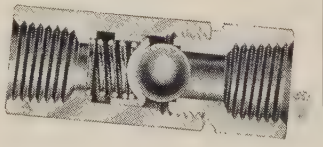
Save weight and space with Mini-Valves. They have same rated flow as regular size, but are only ¼ the size and weight. Good pressure drop characteristics. Temp. range −65° to plus 400°F. Operating pressure to 5000 psi. One-piece stainless steel body, in tube sizes 4 to 16 (¼″ to 1″ O.D.) Meets or exceeds requirements of MS MIL-V-25675. Port threading MS33514 flareless.



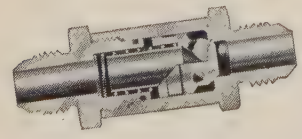
FREE-FLOW CHECKS

Extremely low pressure drop, with wide open flow. Molded elastomer seal and spherical seat prevent leakage at any pressure. Sizes ⅛″ to 2″ in brass and aluminum alloy up to 3000 psi, and stainless steel to 4000 psi. Opens at 2 psi. Temp. range −65° to 200°F. Pipe, internal straight thread and flared tube connections standard; MS33514 flareless available.

BALL CHECKS



Ruggedly constructed for intermittent non-shock hydraulic service up to 500 psi at temperatures −65° to 350°F. Sizes ⅛″ to ¾″. Brass, aluminum alloy, stainless steel. Pipe and flared tube connections.



HY-PRESSURE CHECKS

Built for continuous service in high velocity systems at pressures up to 5000 psi in steel and stainless steel, and 3000 psi in aluminum alloy. Low pressure drop. Metal-to-metal seal. Operating temperatures −65° to 250°F. Sizes ⅛″ to 2″, with pipe, internal straight thread and flared tube connections. MS33514 flareless available.

Distributors in principal cities coast to coast

RM REPUBLIC MANUFACTURING CO.

15655 BROOKPARK ROAD • CLEVELAND 35, OHIO

Write in No. 222 on Reader Service Card

TRANSDUCER for linear motion

This velocity transducer measures the speed of linear motion and generates a direct current output signal proportionate to the velocity of linear displacement, without any excitation. It consists of two coils potted in a stainless steel housing, and a permanent magnet moving in the bore of the housing, says **Vinson Mfg. Co., Dept. S/A, 8044 Woodley Ave., Van Nuys, Calif.**

An output voltage is induced in the coils proportional to the linear velocity of core relative to housing.

Sensitivity range is 100 mvs per inch per second to one volt per inch, per second. Coil impedance increases with length and sensitivity and varies from 300 ohms to 30 K ohms, depending upon application requirements. Temperature ranges are —65 deg to +300 deg F and —100 deg to +500 deg F.

Write in No. 329 on Reader Service Card

SERVO ACTUATOR for drone aircraft

This rotary servo actuator, designated UMC type 6945, is designed for aileron and elevator control on target drone aircraft. It is a light-weight, compact power source for use where fast response, intermittent or continuous operation with high reliability is required, says **Universal Match Corp., Armament Div., Dept. S/A, 472 Paul Ave., St. Louis 35, Mo.** It has a torque rating of 70 inch-pounds at 8.5 rpm.

Internal reversing relays, centering and limit switches, plus a precision potentiometer for position indication furnishes operation range in an open or closed loop positioning system. Present limits are offered for any angle up to 360 degrees.

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871A

Improved FEL-PRO C5-A "HI-TEMP" ANTI-SEIZE THREAD COMPOUND

delivers MORE dollar value at same LOW COST!

All These New Improvements—

NEW • Lower breaking and running torque
NEW • Non-settling, non-hardening, homogenized composition
NEW • Can be used in below freezing weather
NEW • Increased lubricating and sealing qualities
NEW • Prevents rust and corrosion

Now in tubes and cans

FREE TEST SAMPLE PROVES HOW!

You'll save countless man hours and avoid costly replacement of broken studs, bolts, etc., with the protective cushioning action provided by the colloidal copper composition of C5-A. Improved C5-A Lubricates and Seals for fast, easy application and removal. Gives same protective performance even after high-pressure, high-temperature use, up to 1800° F. Can be used on all metals and plastics.

- ✓ Ends seizing and galling even up to 1800° F.
- ✓ Reduces wrench torque
- ✓ Stops needless stud breakage
- ✓ Permits repeated re-use
- ✓ Speeds assembly and disassembly
- ✓ Prevents galling of stainless steel

TRY C5-A NOW . . .

You'll find it ideal for aircraft uses such as slip joints, manifold studs, turbo blowers, etc. *Write for your free test sample today!*

FELT PRODUCTS MFG. CO.
Dept. 52, 7450 N. McCormick Blvd., Skokie, Illinois

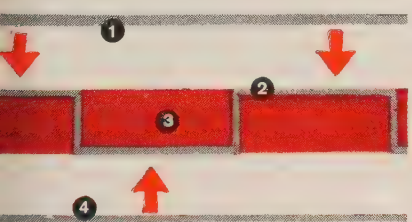
Write in No. 189 on Reader Service Card

Johns-Manville Announces... MIN-KLAD INTERLOK

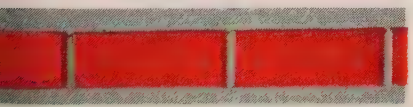
. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

issile experience shows that in certain eat control situations no one material ill perform as well as two (or more)— *insulation with protective high-temperure facings.*

Problem is how to effectively combine ese materials into a structurally strong it? The answer is Min-Klad Interlok



Outer facing, 2) Interlocking web, 3) Core, y one of several Min-K formulations, and Inner facing.



l the above components combine to provide a stom-made structural strong insulating system.

—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

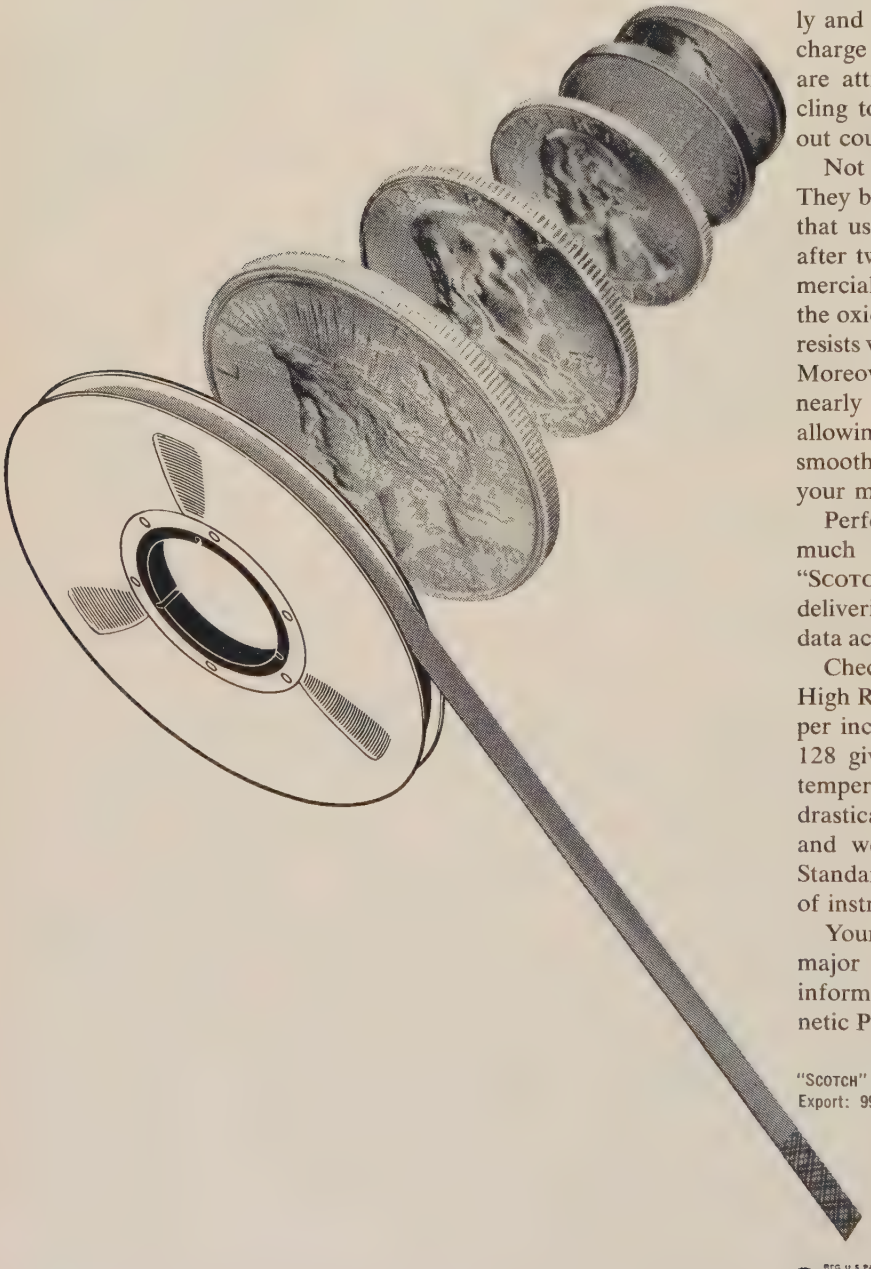
Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Write in No. 223 on Reader Service Card at start of Product Preview Section

A GOOD RUN FOR YOUR MONEY—

New "SCOTCH" BRAND Heavy Duty Tapes offer exceptional life, low rub-off, good resolution



HAVE PROBLEMS OF TAPE-LIFE, rub-off and reso tion? To cure your headaches in applications th subject magnetic tape to high speeds, pressur temperatures and low humidity, "SCOTCH" BRA now prescribes two new tapes—Heavy Duty Tap 198 and 199. They offer plus-performance in a wi variety of temperature and humidity conditio

Take the matter of wear, for instance. Field te show that "SCOTCH" BRAND Heavy Duty Tapes we five times longer than standard tapes—yet th maintain good resolution and freedom from dr outs over this long haul. Two factors are decisive this performance—resistance to rub-off and resi ance to high temperatures.

Ordinary tapes age fast if the temperature clim or the relative humidity drops sharply. The bin softens, allowing the oxides to rub off on those cc ly and sensitive heads.. Further, as an electrosta charge builds with each pass, stray contamina are attracted to the tape—and the tape starts cling to the equipment. In each case—your dr out count mounts.

Not so with "SCOTCH" BRAND Heavy Duty Tap They boast an extra tough binder system similar that used in "SCOTCH" BRAND Video Tape, wh after two years is still the only video tape in co mercial use. The heavy duty binder system anch the oxides firmly to the polyester base in a way t resists very high temperatures—minimizing rub- Moreover, Heavy Duty Tapes have a conductiv nearly 1000 times greater than conventional tap allowing static charge to drain off. Result? Cle smooth runs with good resolution—a good run your money.

Performance of this kind is easy to promis much harder to deliver. And only experien "SCOTCH" BRAND technology has such a record delivering the right tape for every application data acquisition, reduction or control programm

Check all the tapes in the "SCOTCH" BRAND li High Resolution Tapes 158 and 159 pack more per inch, offer extra play time. High Output T 128 gives top output in low frequencies, even temperature extremes. Sandwich Tapes 188 and drastically cut head-wear, eliminate oxide rub- and wear 10 times longer than ordinary tap Standard Tapes 108 and 109 remain the stand of instrumentation.

Your 3M Representative is close at hand in major cities—a convenient source of supply information. For details consult him or write M netic Products Div., 3M Co., St. Paul 6, Minn.

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SCOTCH BRAND MAGNETIC TA

FOR INSTRUMENTATION

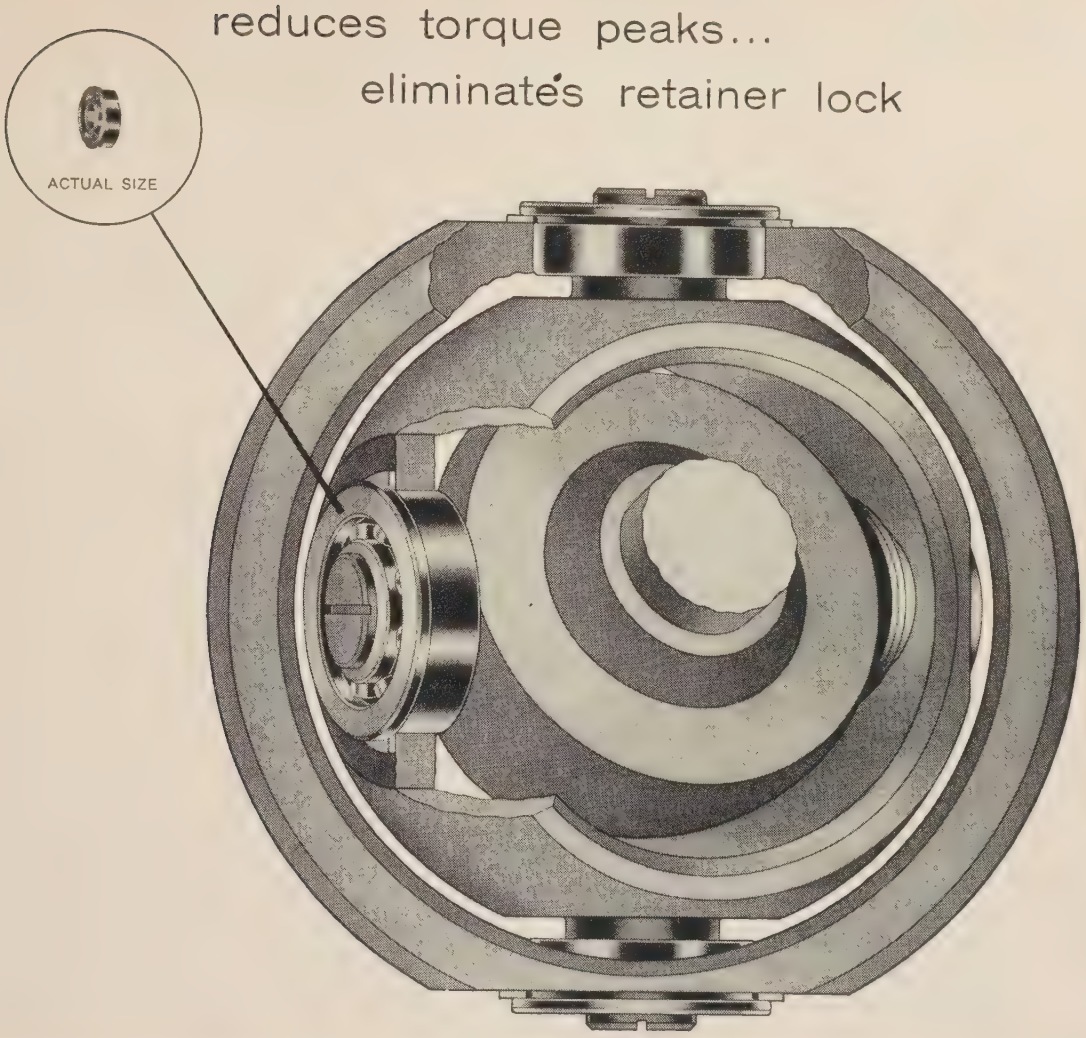
MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPA

Write in No 224 on Reader Service Card at start of Product Preview Section

BARDEN "W" retainer reduces torque peaks... eliminates retainer lock



ow-torque reliability for gyros, synchros and other torque-sensitive components

"W" retainer bearings are available flanged or unflanged, shielded or open, in sizes most in demand ⅝" O.D. and under. For complete technical information write for engineering data sheet W-1.

An instrument bearing that passes all normal torque tests can develop excessive torque peaks in operation. In gyro gimbals, synchros and similar applications the result is erratic component performance. To solve this reliability problem, Barden developed the "W" ball retainer.

Field tested and proved in actual operation, Barden "W" retainer bearings are specified for a growing number of torque-sensitive applications. • • • *In gimbals on the Sidewinder they contribute to the missile's reliability.* • • • *In attitude gyros they save one manufacturer $100 per unit by reducing costly teardown.*

Like other Barden advances in engineering and manufacturing, "W" retainers answer a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

- High temperatures (to above 400°F)
- Low torque (to 10 dyne-cm. for 2 lb. load)
- High speeds (to over 300,000 RPM)
- Concentric rotation (to .00005" max. T.I.R.)

The complete Barden line includes sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. Refer to Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.

r reliability...specify **BARDEN PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 220 Park Ave., Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California

Write in No. 225 on Reader Service Card at start of Product Preview Section

data preview

VALVE LINE—Bulletin 4072, a 12-page release describing a line of self-energizing, high-pressure, pipe-size valves and fittings useful in the missile and chemical processing fields, is available from **American Instrument Co., Inc., Dept. S/A, 8030 Georgia Ave., Silver Spring, Md.** A lens-ring gasket arrangement and union-type joints permit rapid and repeated set-up and dismantling of leak-tight pressure systems.

Write in No. 331 on Reader Service Card

LEAKAGE MEASUREMENT — The Leakmeter Model 400 a device that automatically measures leakage in a pressure line by means of a directly-connected hydraulic assembly, has been described in Bulletin 4-1 by **Convair Instruments/Convair Div., General Dynamics Corp., Dept. S/A, 3595 Frontier St., San Diego 10, Calif.** The device will make accurate measurements under conditions of extreme temperature and is capable of determining very small volumetric expansions.

Write in No. 332 on Reader Service Card

FILTER ASSEMBLIES—Seven basic filter element materials and various series of filter assemblies and replacement elements are described in a bulletin by **Bendix Aviation Corp., Filter Div., Dept. S/A, 434 W. 12 Mile Rd., Madison Hts., Mich.** The materials discussed and illustrated provide particle size control from 1/2 to 250 microns in temperature ranges from —350F to +1500F.

Write in No. 333 on Reader Service Card

HOT GAS SERVO—Electrical-mechanical actuator control for missiles and drones is the subject of bulletin GEA-59APJ-59 prepared by **General Electric Co., Light Military Electronics Div., Dept. S/A, 600 Main St., Johnson City, N. Y.** Typical servo control package with required components is included and data on operation with solid propellant exhaust gases.

Write in No. 334 on Reader Service Card

AMPLIFIER—A 4-page color brochure illustrating their line of wide band, I-F and transistorized amplifiers and pre-amplifiers is available from **Instruments for Industry, Inc., Dept. S/A, 101 New South Rd., Hicksville, N. Y.** In addition to each model being illustrated, detailed specifications and descriptions are also included.

Write in No. 335 on Reader Service Card

SSB ADAPTER SYSTEM—A four-page illustrated brochure describing their production model SSB adapter system is available from the **Kahn Research Laboratories, Inc., Dept. S/A, 22 Pine St., Freeport, N. Y.** The modern technique to convert existing AM communication transmitters to single sideband operation without engineering modification is described in detail.

Write in No. 336 on Reader Service Card

FLIGHT CONTROLS—Bulletin GEA-59APJ-67 contains descriptions including operating features of complete line of flight controls available from **General Electric Co., Light Military Electronics Div., Dept. S/A, 600 Main St., Johnson City, N. Y.** Photos, exploded views, and cutaway drawings support the text.

Write in No. 337 on Reader Service Card

DATA EQUIPMENT—A 4-page bulletin describing Learoaide, a visual-audio training unit which synchronizes a color slide projector with a customized tape-recorder is available from **Lear, Inc., Grand Rapids Div., Dept. S/A, 1110 Ionia Ave., N. W., Grand Rapids 2, Mich.**

Write in No. 338 on Reader Service Card

FACILITIES — A 12-page illustrated color brochure describing the facilities and products of their Microwave Division is available from **Kearfott Co., Inc. Microwave Div., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.**

Write in No. 339 on Reader Service Card

INSTRUMENTATION RECORDER—A four color brochure is available on the new FR-600 instrumentation recorder, which offers a frequency response to 250 Kc in direct recording and to 20 Kc in FM work, says **Ampex Corp., Instrumentation Div., Dept. S/A, 934 Charter St., Redwood City, Calif.** Full specifications and descriptions of accessories, optional equipment and "human engineering" design are included.

Write in No. 340 on Reader Service Card

MOON MAP—Printed in a large size, a moon map making all charted geography of the visible side of the moon easily identifiable and located may be obtained from **General Electric Co., Missile & Space Vehicle Div., Dept. S/A, 3198 Chestnut St., Philadelphia 4, Pa.**

Write in No. 341 on Reader Service Card

VIDEO TRANSFORMATION TUBE—A bulletin concerning the TMA-403X Video Transformation Tube is available from **Intercontinental Electronics Corp., Dept. S/A, 1551 Franklin Ave., Mineola, N. Y.**

Write in No. 342 on Reader Service Card

SAGE—A report featuring a summary of the Sage air defense system and describing some of the unique problems encountered in the system's construction is available from **Burns & Roe, Inc., Dept. S/A, 160 West Broadway, New York 13, N. Y.** Some typical design considerations, such as, accurate temperature and humidity control for electronic devices, fail-proof power generation are outlined in the report.

Write in No. 343 on Reader Service Card

SUBSYSTEM COMPONENTS—A 6-page booklet describing their all-electronic subsystem components for aviation is available from **Lear, Inc., Astronics Div., Dept. S/A, 3171 South Bundy Drive, Santa Monica, Calif.**

Write in No. 344 on Reader Service Card

PROTECTIVE SURFACES—"How To Use HuniSeal Protective Surface Coatings in Electronic Applications" is the subject of a 20-page booklet just released by **Columbia Technical Corp., Dept. S/A, 61-05 31st Ave., Woodside 77, N. Y.** Filled with many useful tips, the booklet covers highly informative phases of applying humidity-proof protective surface coatings.

Write in No. 345 on Reader Service Card

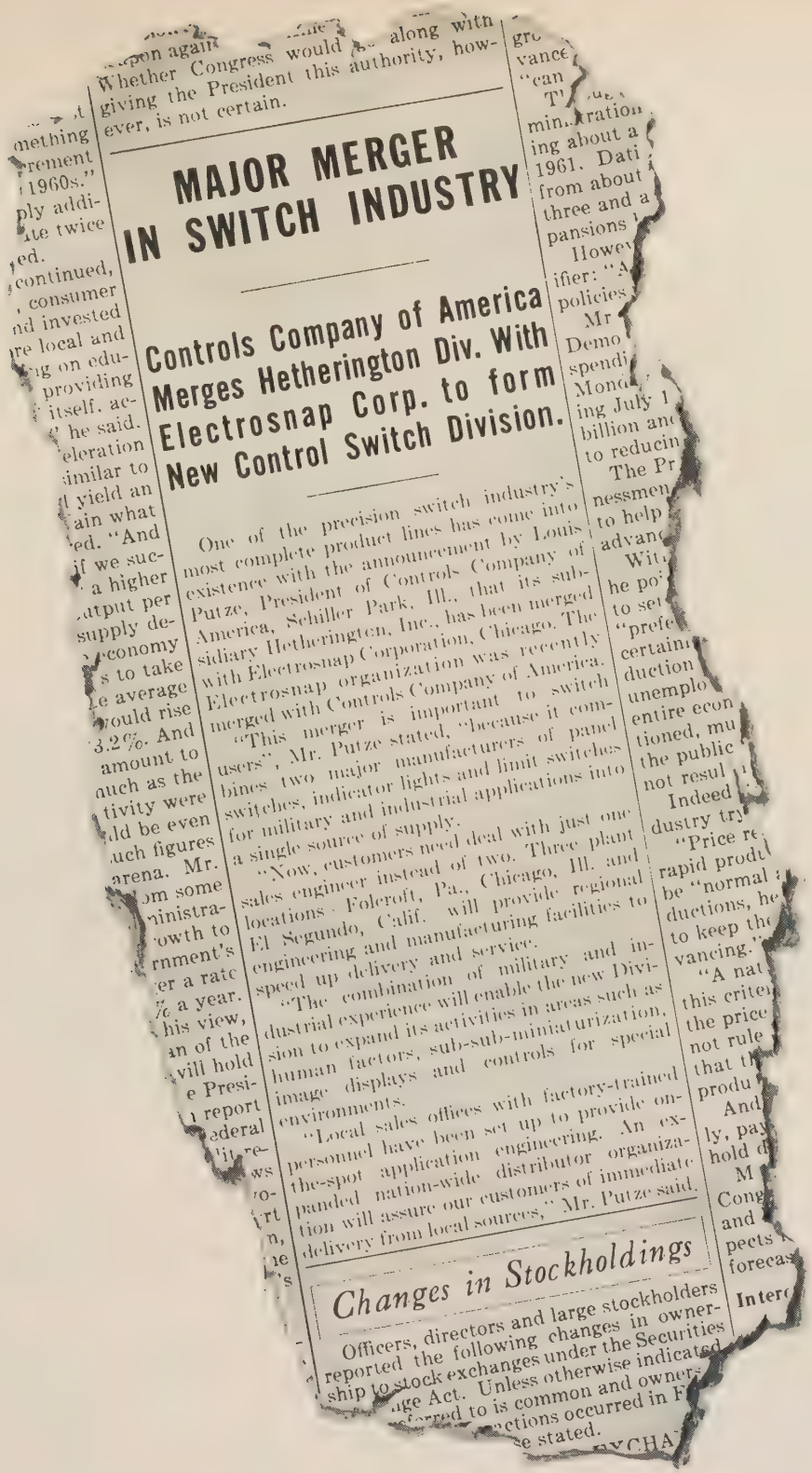
RADIATION SIGNS — Embossed plastic signs are described in a data sheet by **Ad-O-Plastic, Dept. S/A, P. O. Box 474, Woodbridge, N. J.** It lists dimensions and prices for the radiation warning signs.

Write in No. 346 on Reader Service Card

FIELD SERVICE—An 8-page illustrated brochure describing their field service capabilities is available from **Hoffman Electronics Corp., Laboratories Div., Dept. S/A, 3740 South Grand Ave., Los Angeles 7, Calif.** The book outlines the field services Hoffman offers on a world-wide basis in the areas of field engineering, overhaul and repair, test equipments, standards, training and medical electronics.

Write in No. 347 on Reader Service Card

more on page 280



Whether Congress would go along with giving the President this authority, however, is not certain.

MAJOR MERGER IN SWITCH INDUSTRY

Controls Company of America Merges Hetherington Div. With Electrosnap Corp. to form New Control Switch Division.

One of the precision switch industry's most complete product lines has come into existence with the announcement by Louis Putze, President of Controls Company of America, Schiller Park, Ill., that its subsidiary Hetherington, Inc., has been merged with Electrosnap Corporation, Chicago. The Electrosnap organization was recently merged with Controls Company of America.

"This merger is important to switch users", Mr. Putze stated, "because it combines two major manufacturers of panel switches, indicator lights and limit switches for military and industrial applications into a single source of supply.

"Now, customers need deal with just one sales engineer instead of two. Three plant locations - Foleroft, Pa., Chicago, Ill. and El Segundo, Calif. will provide regional engineering and manufacturing facilities to speed up delivery and service.

"The combination of military and industrial experience will enable the new Division to expand its activities in areas such as human factors, sub-sub-miniaturization, image displays and controls for special environments.

"Local sales offices with factory-trained personnel have been set up to provide on-the-spot application engineering. An expanded nation-wide distributor organization will assure our customers of immediate delivery from local sources," Mr. Putze said.

Changes in Stockholdings

Officers, directors and large stockholders reported the following changes in ownership to stock exchanges under the Securities ...ge Act. Unless otherwise indicated ...ferred to is common and owner... ...ctions occurred in F... ...e stated.

ELECTROSNAP
HETHERINGTON

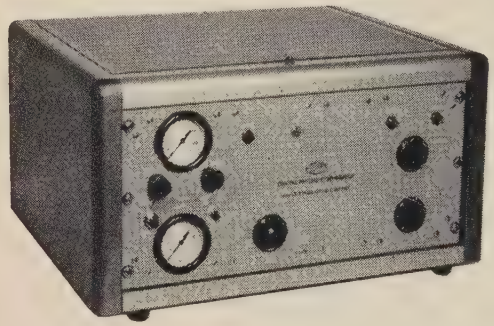
CONTROL SWITCH DIVISION

CONTROLS COMPANY OF AMERICA
4218 W. Lake Street • Chicago 24, Illinois
Telephone: VAn Buren 6-3100 • TWX No. CG-1400

VISIT BOOTH 1727, A&B AT I.R.E. SHOW

Write in No. 226 on Reader Service Card at start of Product Preview Section

BREAKTHROUGH IN THE SCIENCE OF PRESSURE CONTROL



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reliability
crystal-determined
accuracy

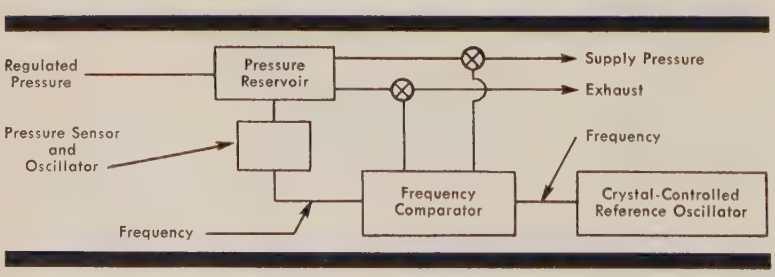
WIANCKO'S Q3700 SERIES DIGITAL PRESSURE GENERATOR

This system, employing unique digital-servo concepts, provides instant selection of a pneumatic pressure accurate to ±0.05 PERCENT.

Pressure in a reservoir is measured and converted to a precision frequency. This frequency is compared with a selected reference frequency. If the frequency from the pressure sensor is high with respect to the reference frequency, the comparator produces a difference frequency in the form of pulses. These pulses then drive momentary exhaust valves until the pressure drops to the pre-selected value. When the frequency is low, error signals are produced which operate momentary pressurizing valves. The Q3700 is the best answer yet to pressure control and calibration problems.

Ideal for:

- *Programming precision pressure/time functions*
- *Automatic end-to-end calibration of data and telemetering systems*
- *Rapid calibration of pressure devices*
- *Ground checkout of instrument and control systems*



For complete information please request Product Bulletin 111

WIANCKO
ENGINEERING COMPANY

Precision with lasting reliability

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Write in No. 227 on Reader Service Card at start of Product Preview Section

WELDING CONTROL—Five units for the sequence timing of welds have been described in a four-page bulletin entitled "Programed Time-Amperage Control for Critical Welding," available from **Harnischfeger Corp., Dept. S/A, 4400 W. National Ave., Milwaukee 46, Wisc.** The control devices include motorized rheostat controls, punched-tape programing, and sequence timers.

Write in No. 348 on Reader Service Card

SILVER-ZINC BATTERIES—Performance features of secondard (rechargeable) silver-zinc batteries for electronic equipment, underwater apparatus, industrial communications systems, etc., are explained in an illustrated brochure by **Telecomputing Corp., Cook Batteries Div., Dept. S/A, 3850 Olive St., Denver 7, Col.** It includes drawings of design applications, including use in major weapons systems for powering telemetry instrumentation, guidance and control systems, range safety, warhead arming and separation functions. Battery discharge cycle capability, shelf life, reliability, weight and output factors are detailed in specification charts and dimensional tables.

Write in No. 349 on Reader Service Card

GRAPHITE—Reprint of the article "Graphite—How it Compares with Metals, Ceramics," by Glen B. Engle and Dr. L. M. Liggett, is offered by **Speer Carbon Co., Dept. S/A, St. Marys, Pa.** Comparative data on electrical resistivity, tensile strength and modulus, strength-to-weight ratio and thermal conductivity are presented graphically. Coefficients of thermal expansion are listed.

Write in No. 350 on Reader Service Card

FACILITIES — A facilities brochure, describing the space-age capabilities for research and development, environmental and systems testing, precision production, and reliability control, and products has been issued by **Vap-Air, Dept. S/A, 6420 W. Howard St., Chicago 48, Ill.** It includes air temperature control systems, mercury thermostats, in-line valves, windshield temperature controllers, electropneumatic temperature control systems and cooling effect detector.

Write in No. 351 on Reader Service Card

HEAT EXCHANGERS—Types of fired heat exchangers are discussed in bulletin No. 113 by **Thermal Research & Engineering Corp., Dept. S/A, Conshohocken, Pa.** It includes 5 standard types, giving ranges of Btu/hr duty, pressure and temperature ratings, and typical pressure drops. Special designs are also described.

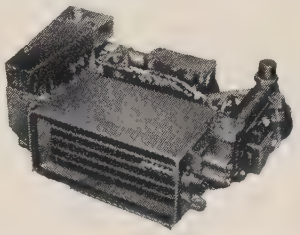
Write in No. 352 on Reader Service Card

more on page 284

"BLOWING YOUR STACK" OVER ELECTRONIC CONTROL? LET UAP HELP YOU!

UAP has the specialized capabilities needed to analyze your over-all problem; apply the system technique; integrate components and subsystems into complete operational systems to achieve specific functions such as *temperature, mechanical* and *mass flow* control.

Example: UAP was assigned the expendable refrigerant system responsibility for an unmanned supersonic target drone built by Radioplane Division of Northrop Corporation. This cooling system consists of an electronic control assembly that maintains a constant mass air flow, regardless of pressure variations. It also schedules the quantity of anhydrous ammonia expendable refrigerant from the pressurized ammonia tank. Constant temperature is thus maintained to the compartments which house electronic flight-controlling equipment.



U-524133-1 Expendable Refrigerant System

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(Contractual Engineering Offices: California, Gardena FA 1-4810; New York City MU 7-1283; Dayton, Ohio BA 4-3841; Canada, Montreal OX 7-0810)
WESTERN DIVISION, UAP, INC., Box 20, Gardena, California

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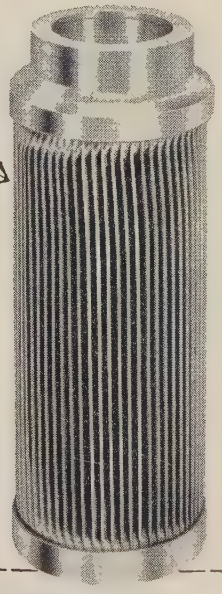
There's never been a filter element that could do all this

IT'S A PUROLATOR PRESSURE LOCK FILTER ELEMENT AND LOOK WHAT IT DOES:

- Gives you a filter that's free of built-in contamination
- Boosts top temperature limit of conventional stainless steel mesh filter to 1000°F or more
- Cuts 43% off the weight of an identical filter assembled by conventional bonding methods
- Significantly increases available element filtering area
- Withstands collapse pressure of more than 4500 psi
- Filters any known hydraulic fluid
- Meets requirements of specifications MIL-F-5504B and the proposed MIL-F-8815.



Only Pressure Lock will do it, and this is why:

Pressure Lock is an exclusive Purolator process of assembling a wire-mesh filter medium without welding, brazing or cementing, and without the contamination that any of these methods produce. Pressure Lock embeds the filter medium in the end caps in an absolute bond that contains no material other than the metal of the cap and filter medium. As a result, the only limitation on the performance of a Pressure Lock filter — temperature, pressure, vibration, filtration or weight — is the physical properties of the construction metals.

Present ratings are for a nominal 10 micron (absolute maximum particle size of 25 microns) and for a nominal 5 micron (absolute maximum particle size of 15 microns); in capacities of ½, 3, 6 and 12 GPM. Higher capacity elements are being processed for early production.

The Pressure Lock process provides, literally, a new standard for filter applications in aircraft and missiles, industrial hydraulics, pneumatics and chemical process industries. Fill in the coupon and send it now for further information.

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Please send complete data on Purolator filters with Pressure Lock elements.

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LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

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The wide range of Iridite coatings available gives you a choice of corrosion protection—from economical, mild protection of parts for shipment, storage or display, to extremely high protection under exposure to marine and highly humid atmospheres, gasoline or other hydrocarbons.

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For an extremely tight bond for either baked or air-dried paints, non-porous Iridite blocks moisture penetration—prevents formation of metallic soap products beneath paint coatings.

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Your choice of colors ranging from clear through yellow iridescent to olive drab. Bright Iridite finishes can also be dyed to provide other color effects.

SPECIAL EFFECTS

Iridite, in combination with other Allied Research processes, can provide a wide variety of finishes. As an example, Iridite 8-P applied to zinc or cadmium, followed by an application of Irilac, gives a highly attractive simulated brass finish.

IRIDITE—a specialized line of chromate conversion coatings for nonferrous metals. Easily applied at room temperatures with short immersion times, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel. Special equipment, exhaust systems or highly trained personnel not required.

For complete information on Iridite, contact your Allied Field Engineer. He's listed in the yellow pages under "Plating Supplies." Or, write for FREE TECHNICAL DATA FILES.

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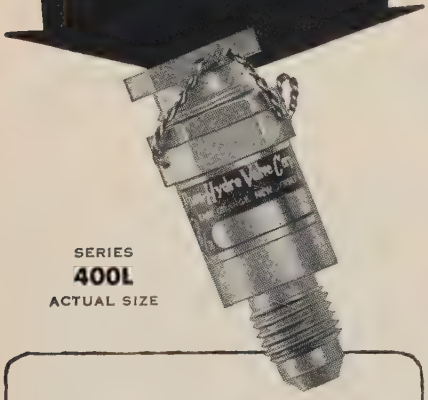
Pneu-Hydro

SUBMINIATURE

PRESSURE RELIEF VALVES



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DATA PREVIEW

FILTERS—A 350-page catalog No. 61 carrying design and engineering data as well as product information on interference suppression devices for electronic equipment is available from **Filtron, Inc., Systems Div., Dept. S/A, 10023 W. Jefferson, Culver City, Calif.** This is Catalog No. 61.

Write in No. 353 on Reader Service Card

POTENTIOMETERS—A catalog detailing information on box type and rotary trimmers, panel controls, precision servo type potentiometers, nonstandard function pots and special non-linear pots is now available from **Technology Instrument Corp., Dept. S/A, 531 Main St., Acton, Mass.** It includes pressure and displacement transducers, unitized clutch modules with synchros, servo motors, spring returns, brakes, commutator switches, magnetic clutches and single or multiturn potentiometers.

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CLEANING—An ultrasonic cleaning equipment primer which explains what it is, how it works, areas to be employed, and solvents and detergents for use with this kind of equipment has been prepared by **National Ultrasonic Corp., Dept. S/A, 111 Montgomery Ave., Irvington, N. J.** It describes applications, compounds and principles.

Write in No. 355 on Reader Service Card

INPUT SCANNER — A bulletin describing specifications and features of a multiple point input scanner is available from **Kin Tel Div., Cohu Electronics, Dept. S/A, 5725 Kearny Villa Rd., San Diego 12, Calif.** The bulletin describes the Kin Tel Model 453 M scanner, an extremely flexible and versatile input device designed for any application where a number of signals must be scanned.

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MAGNETORESISTOR—A 4-page illustrated brochure describing the MS-41 Magnetoresistor, a new solid state device, is available from **Ohio Semiconductors, Inc., Dept. S/A, 1035 W. Third Ave., Columbus 8, Ohio.**

Write in No. 357 on Reader Service Card

VIBRATION & SHOCK — A technical manual to aid engineers in solving objectionable vibration and shock conditions has been prepared by **Voss Engineering, Inc., Dept. S/A, 5649 No. Ravenswood Ave., Chicago 26, Ill.** The Sorbtex manual contains reference charts. It is said to shed new light on isolators of this type in determining paid thicknesses for various applications under machinery.

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more on page 286

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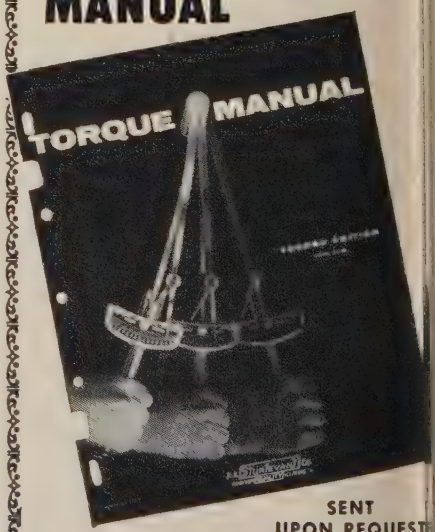
"TORQUE WRENCH" MANUAL



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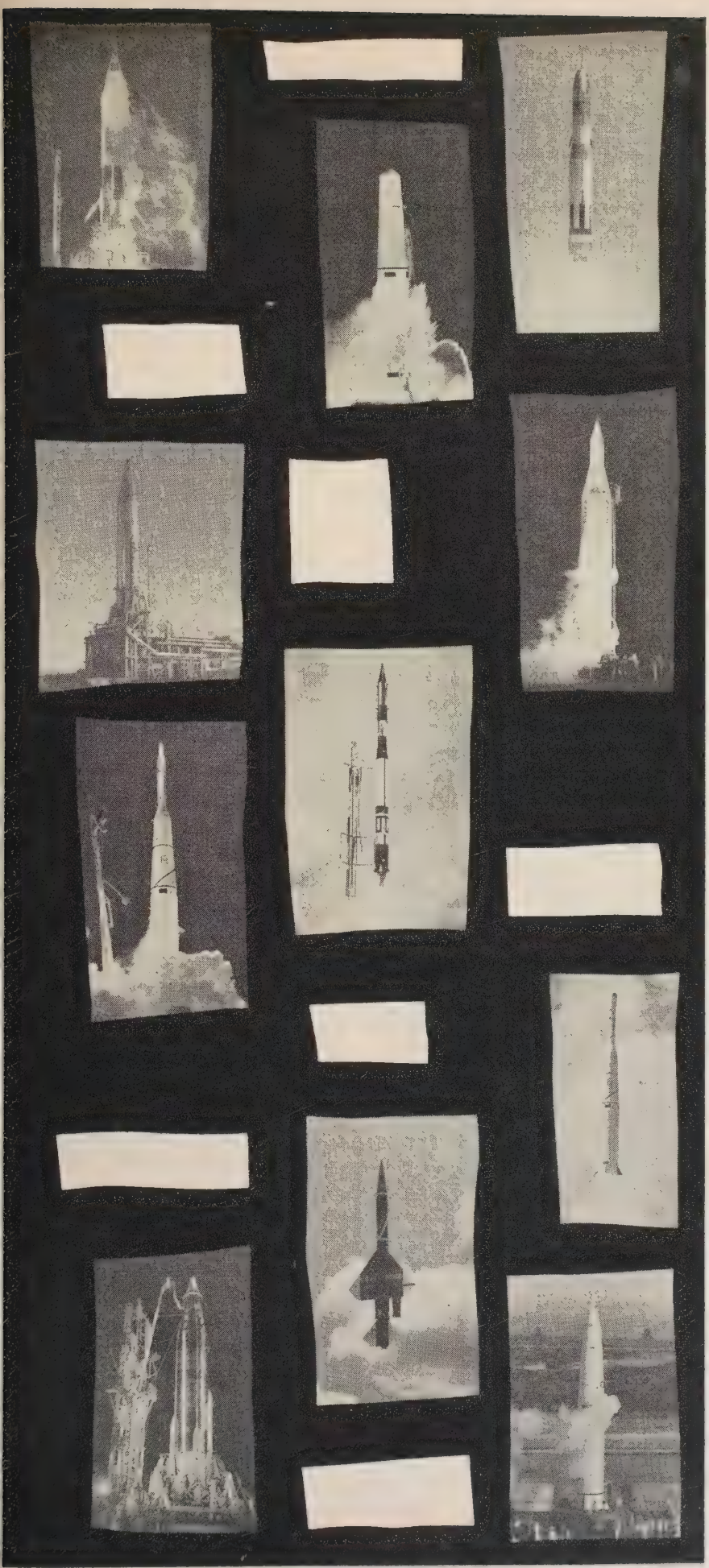

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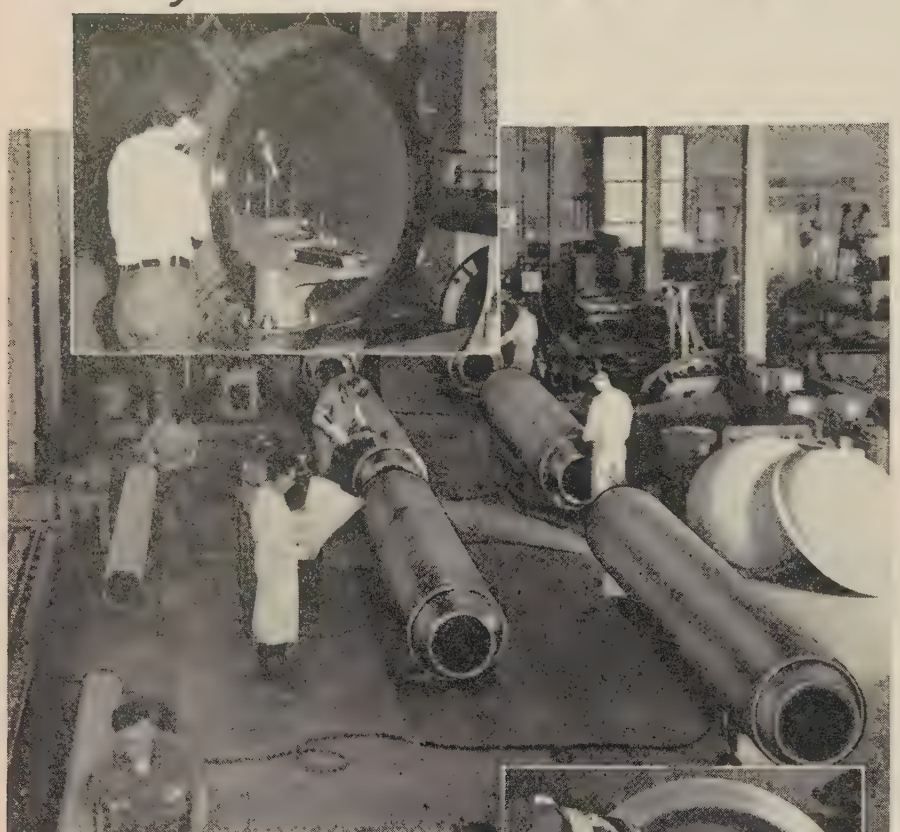
Guided Missiles Range Division

Patrick Air Force Base, Florida

Check Employment Inquiry Form on Page 165

Missile Hardware *by* **NEWBROOK**



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BLOWER—A two-page illustrated 2-color bulletin No. 5812, describing centrifugal air unit No. 89C21 for electronic equipment cooling is now available from **American-Standard Industrial Div., Dept. S/A, Detroit 32, Mich.** The bulletin describes the new unit, listing its outstanding features and recommended applications.

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SEMICONDUCTOR ALLOYS — The physical properties of lead-antimony, tin-antimony, tin-gold and other semiconductor alloys are described in a series of technical data sheets prepared by **Alpha Metals, Inc., Dept. S/A, Jersey City, N. J.** The data sheets come in a handy file folder and are specially punched to fit a variety of binder styles.

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GEARED COUNTER — A data sheet and application guide that describes the operation, uses and modifications on high speed, quick reset geared counters has been prepared by **Veeder-Root, Inc., Dept. S/A, Hartford 2, Conn.** It includes double shaft extension, reset, forked-coupling, friction wheel drive or plain shaft.

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NUCLEAR INSTRUMENTS — Nuclear instruments and monitoring systems are discussed in illustrated bulletin C by **Victoreen Insrumen Co., Dept. S/A, 5806 Hough Ave. Cleveland 3, Ohio.** More than 50 instruments and systems are included such as amplifiers, scalers, rate meters, power supplies, electrometers, accessory instruments, spectrometers, radiation monitoring systems, medical and survey instruments. Design uses, and performance data are included.

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FACILITIES—A 28-page booklet describing how elecronic, mechanical and optical research and production have been major factors in elevating aerial photography to the functional versatile tool that it is, is available from **Chicago Aerial Industries, Dept. S/A, 1980 Hawthorne Ave., Melrose Park, Ill.**

Write in No. 363 on Reader Service Card

COMPUTER—A 14-page catalog No. S1 describes SPEC, a new general purpose digital computer and digital differential analyzer plus a logical design implementer, is available from **Computer Controls Co., Inc., Western Div., Dept. S/A, 2251 Barry Ave., Los Angeles 54, Calif.** Operation codes, typical programs, block diagrams, physical components and specifications are shown.

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more on page 288

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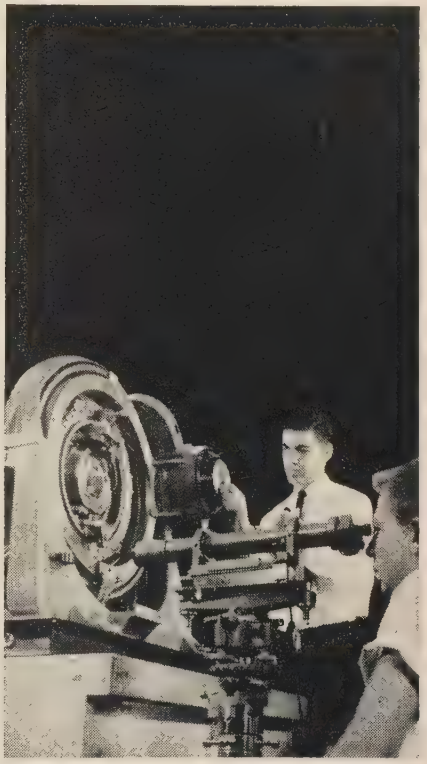

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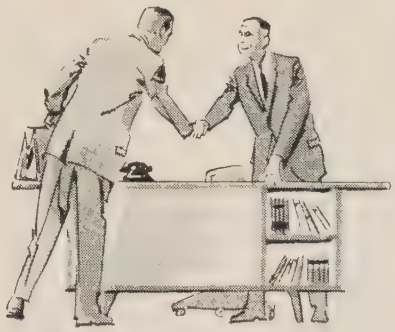

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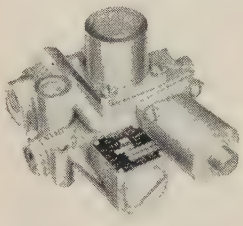
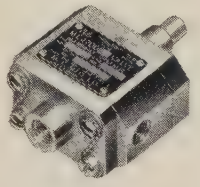
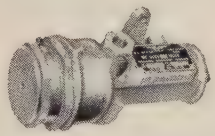


- SOLENOID VALVES



- SELECTOR VALVES



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DATA PREVIEW

MEASURING VSWR—A 2-page data sheet entitled "How To Measure VSWR" is available from **Polytechnic Research & Development Co., Inc., Dept. S/A, 201 Tillary St., Brooklyn, 1, N. Y.**

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AUTOMATIC TEST SYSTEMS—Automatic testing microwave and antenna test instrumentation, radome testing systems, and flight simulation equipment are the four categories covered in a twelve-page, two-color catalog describing the entire product line of **California Technical Industries Div., Textron Inc., Dept. S/A, 1421 Old County Road, Belmont, Calif.**

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WIRING DEVICES—Basic types of electric terminals and connectors ranging from the "ring" and other standard tongue designs through multiple-wire connectors and quick-disconnects are discussed in a brochure by **ETC, Inc., Dept. S/A, 990 E. 67th St., Cleveland 3, Ohio.** Barrel styles are illustrated, including insulated, non-insulated and vibration-proof styles. Performance features are compared. Cutaway views show construction details.

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ROCKET TARGET—Method of operation, capabilities and general details of Skydart I, an expendable, low-cost, air-launched, intermediate-range rocket-powered target, are fully described in an illustrated catalog prepared by **Curtiss-Wright Corp., Dept. S/A, 6767 Hollister Ave., Goleta, Calif.**

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POWER SUPPLIES — Data sheets describing their airborne transistorized power supplies Models TPC-18 and 19A are available from **Southwestern Industrial Electronics Co., Dept. S/A, 10201 Westheimer Rd., Houston 19, Texas.**

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ACCELEROMETERS—The series 2200 accelerometers are the subject of an illustrated manual by **Endevco Corp., Dept. S/A, 161 E. California Blvd., Pasadena, Calif.** It serves as an instruction manual with coverage of dynamic accelerometer methods and techniques.

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FILTERS—A 4-page illustrated brochure describing the capabilities of their R.F. filters is available from **C. A. Rypinski Co., Dept. S/A, 2005 North Fair Oaks Ave., Pasadena, Calif.**

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more on page 290

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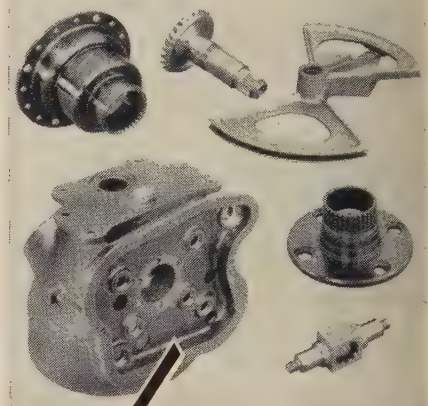

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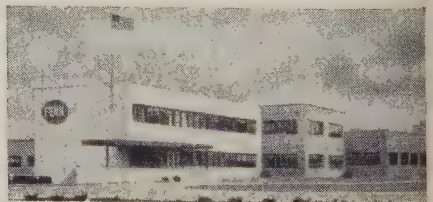
- Currently in production—helicopter main rotors, and gear boxes, parts for gas turbine and jet aircraft engines, components for nuclear reactors
- Write for Facilities Folder. The Fenn Manufacturing Company, Fenn Road, Newington, Connecticut.



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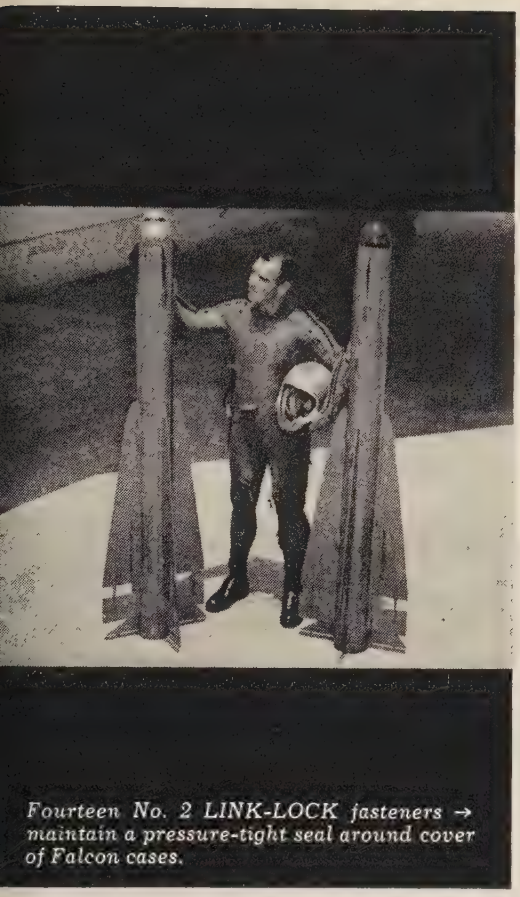
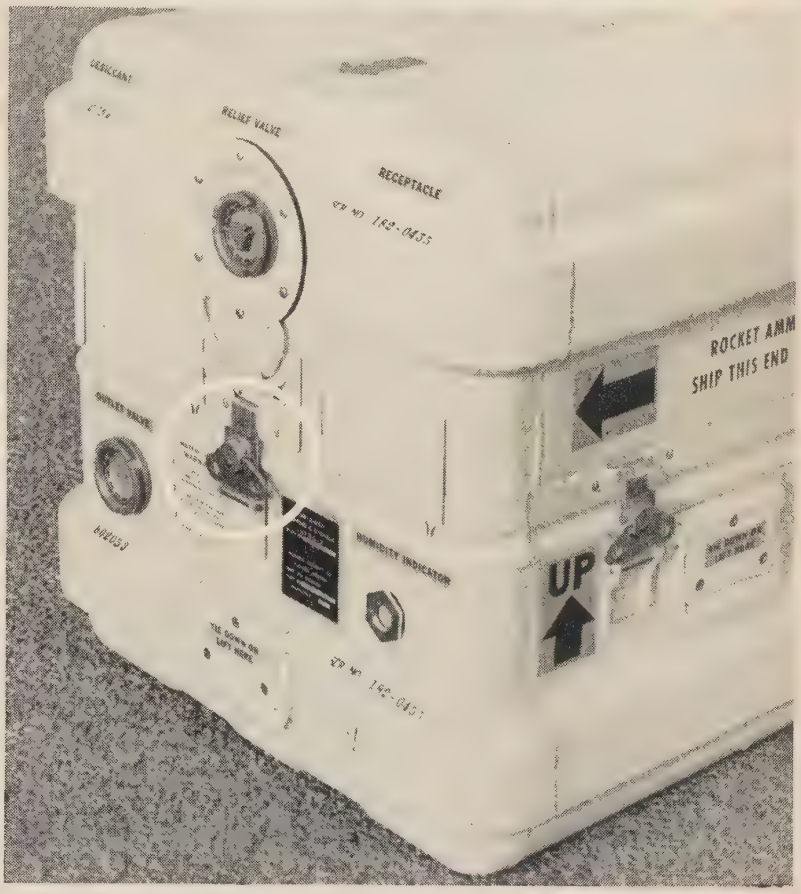
Falcon missiles travel "first class" in containers secured by LINK-LOCK



Fourteen No. 2 LINK-LOCK fasteners → maintain a pressure-tight seal around cover of Falcon cases.



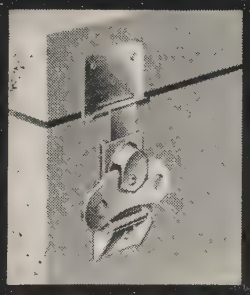
Before they take to the skies, Falcon air-to-air guided missiles are shipped or stored in containers sealed pressure-tight by Simmons LINK-LOCK fasteners.

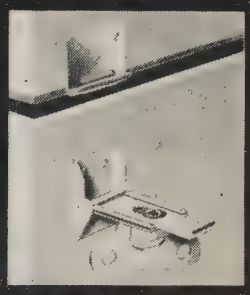
These precisely engineered fabricated aluminum cases are produced to Hughes Aircraft Company specifications by the following companies: Vendorlator Manufacturing Co., Fresno, California; Allison Steel Manufacturing Co., Phoenix, Arizona; Avco Corporation, Crosley Division, Richmond, Indiana.

Features like these make the LINK-LOCK ideal for use on military cases made to rigid specifications as well as on inexpensive commercial containers:

- Impact and drop resistant.
- Positive-locking without springs.
- High preloading and high load carrying capacity.
- Compact design—lies flat open or secured.
- 3 sizes, for heavy, medium, light duty.
- Flexible engagement latch design...can be varied to suit different applications.

Write for Catalog #1257. Contains complete details of LINK-LOCK and other Simmons Fasteners with unlimited money-saving applications. Samples and engineering service available on request.





Half-turn applies high closing pressure, counter-turn disengages for opening. LINK-LOCK lies flat open or closed.

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QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK
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See our 8-page catalog in Sweet's Product Design File

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Model 320 DY

OUTSTANDING FEATURES:

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INERTIAL PLATFORM — An eight-page bulletin GEA-59-PJ-65A, describing a new gimbal platform which operates from -55 to +100 deg C in very high acceleration environments, is available from **General Electric Co., Light Military Electronics Div., Dept., S/A, 600 Main St., Johnson City, N. Y.** The bulletin covers fabrication features, and configuration details of nine platform versions and descriptions of platforms and associated electronic components.

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HUMAN ENGINEERING—A 14-page illustrated booklet describing human engineering and its impact of flight research is available from **Sperry Gyroscope Co., Aeronautical Equipment Div., Dept. S/A, Great Neck, N. Y.**

Write in No. 373 on Reader Service Card

TRANSFORMERS—A 4-page bulletin describing their line of high power pulse transformers and inductor devices is available from **Stavid Engineering, Inc., Dept. S/A, Plainfield, N. J.** Bulletin includes specifications on pulse transformers and charging reactors to 100 KV output with 10 amp filament supply.

Write in No. 374 on Reader Service Card

CAPABILITIES—A brochure describing its activities in the manufacture of components and systems for air and space has been released by **Leach Corp., Dept. S/A, 18435 Susan Rd., Compton, Calif.** The company is noted for its work in relays, instrumentation systems, and airborne recording.

Write in No. 375 on Reader Service Card

NOISE SOURCES—Bulletin NS1 describing Series T-44 noise sources from the microwave region is available from **Tucor Inc., Dept. S/A, 18 Marshall St., South Norwalk, Conn.**

Write in No. 376 on Reader Service Card

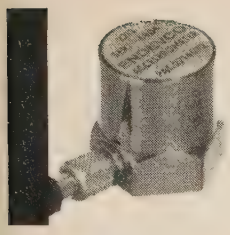
INSTRUMENT COUNTERS—Precision instrument counters for navigational applications, computers, missile tracking, radar, etc., are discussed in a catalog by **Chicago Dynamic Industries, Precision Products Div., Dept. S/A, 1725 Diversey Blvd., Chicago 14, Ill.** It includes dimensional drawings.

Write in No. 377 on Reader Service Card

DIODES—A new characteristics and replacement guide for semiconductor diodes is available from **Sylvania Electric Products, Inc., Dept. S/A, 1100 Main St., Buffalo 9, N. Y.** The new booklet features a section on Sylvania's latest diode manufacturing equipment.

Write in No. 378 on Reader Service Card

more on page 292



FORD VIBRATION INSTRUMENTATION: The Ford Motor Company entered the experimental gas turbine engine field in 1952. The Ford Turbo Machines Department is now engaged in research and development of a turbine engine and a working model has been tested in a tilt-cab truck. An obsolete engine, the Ford 702, has developed 160 horsepower at shaft speeds up to 36,000 rpm. ■ A new supercharged 300 horsepower turbine engine was recently announced by Ford Engineers. Known as the "704," the engine weighs 650 pounds installed, compared to 2,700 pounds for a truck diesel engine of comparable horse-

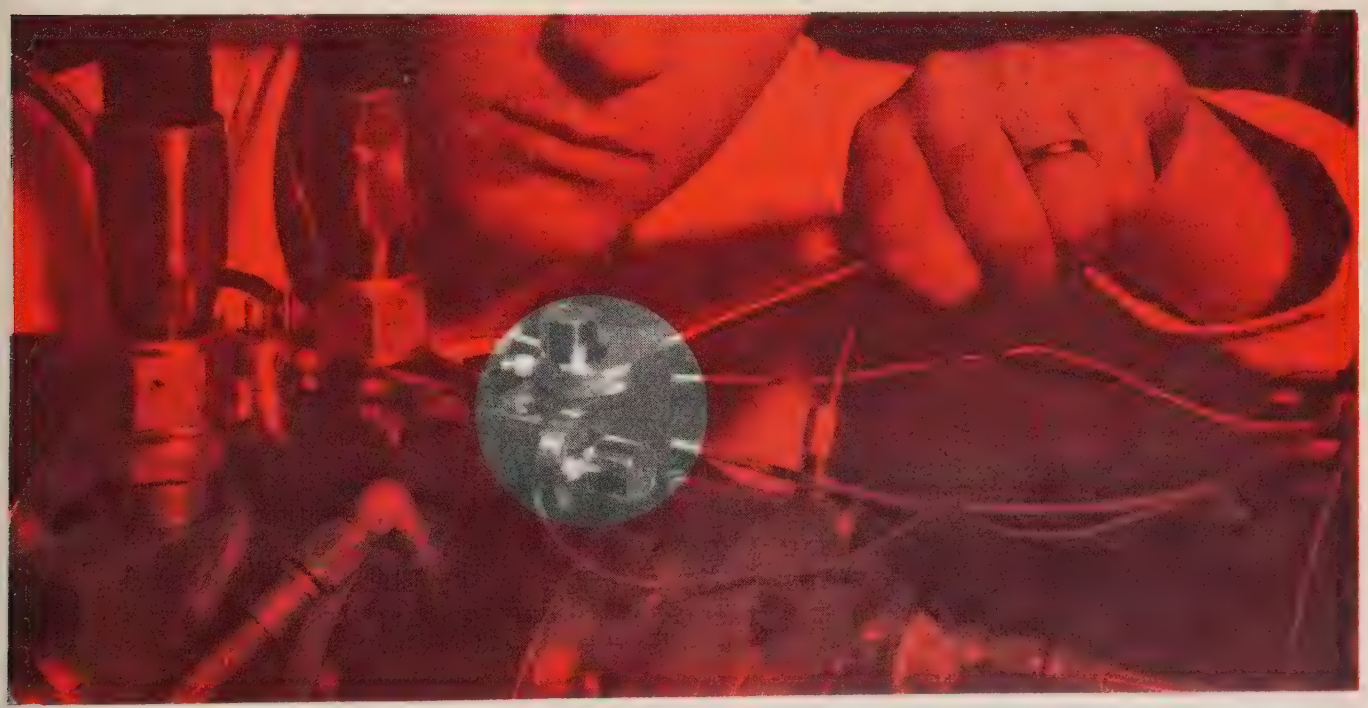
ENDEVCO TRANSDUCERS SOLVE VIBRATION ANALYSIS PROBLEM

power. The engine has two stages of compression, each operating at a 4:1 pressure ratio. Two burners are used for driving the dual compressors, the low speed wheel turning at 46,500 rpm and the high speed wheel at 91,500 rpm.

THE PROBLEM: The Ford Test program requires a wide variety of instruments to measure, control and record performance data of component parts. Measurement of vibration, for example, is a critical factor in this program. Vibrations that may cause metal fatigue, oil film breakdown, overheating, etc., are discovered during tests on individual engine "stands."

THE SOLUTION: Ford engineers use a total of six Endevco Series 2200 Accelerometers providing frequency responses up to 6,500 cycles per second. The accelerometers are connected to bearing test rigs, for example (see photo). The accelerometers relay measurements of acceleration movements in turbine shafts from three coordinates (radial vertical, radial horizontal and axial). Temperatures of the metal housings to which the standard Endevco transducers are attached average up to +150°F. Temperatures at which the water-cooled, heat-resistant models are used range up to +1000°F or more. The large self-generated output of the Endevco accelerometers eliminates the need for additional stabilization of a power supply.

THE RESULTS: The Endevco transducers are attached with a single-pole threaded bolt. The signal is fed through an Endevco amplifier to an oscilloscope or panoramic analyzer. The analyzer concentrates on a small section of the total signal and may present from 4 to 10 harmonic vibrations of different frequencies being fed from the unit at one time. This analyzer separates the frequency bands into individual bands, which it then sweeps from 20 to 40,000 cycles every second, measuring the frequency and amplitude in millivolts. ■ Ford Technicians convert these vibration records by mathematically integrating acceleration with respect to time to obtain the displacement or housing vibration. Thus, they locate the sources of objectionable resonance and take steps to eliminate or reduce vibration in the overall design. ■ Endevco accelerometers have also served as pickups for determining spring rate and damping characteristics of rubber bonded bearings. • **ENDEVCO CORPORATION** • 161 EAST CALIFORNIA BOULEVARD PASADENA, CALIFORNIA • PHONE SYCAMORE 5-0271



Close-up shows two Endevco Accelerometers on bearing test rig in Ford Instrumentation Section, Dearborn, Michigan. Cable passes to Endevco Amplifier (not shown on right).

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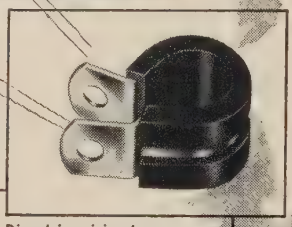

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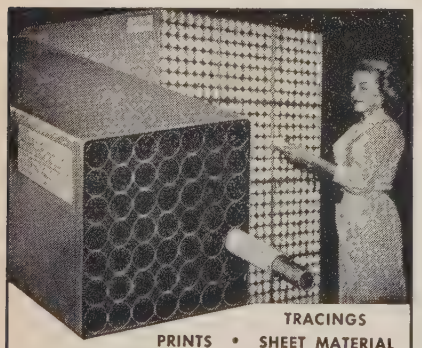

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DATA PREVIEW

SOLENOID VALVE—Engineering data sheet FR 108 describing a no-leak two-way pilot operated solenoid valve has been issued by **Fluid Regulators Corp., Dept. S/A, 313 Gillette St., Painesville, Ohio.** It includes operating specifications, engineering data, dimensional information, and typical flow curve.

Write in No. 379 on Reader Service Card

MOLDED RUBBER PARTS—Molded and extruded rubber parts for use on automobiles, aircraft, machinery, appliances, office equipment and railroad equipment are described in bulletin AD-167 by **The Garlock Packing Co., Dept. S/A, 436 Main St., Palmyra, N. Y.** Detailed description and applications are included, as well as tabular material on tensile strength, elongation, physical properties and effect of environments.

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AUTOPILOT SYSTEM—3 12-page illustrated bulletin describing their adaptive autopilot system is available from **Minneapolis-Honeywell Regulator Co., Aeronautical Div., Dept. S/A, 2600 Ridgeway Rd., Minneapolis 13, Minn.** The autopilot not only compensates for variations control characteristics of a given airplane, but is can be used in any missile aircraft with no major modifications.

Write in No. 381 on Reader Service Card

METAL PACKING—Data for the correct selection, application and installation of metal packing for pumps, engines and compressors are included in Bulletin AD-166, a 24-page booklet issued by **The Garlock Packing Co., Dept. S/A, 438 Main St., Palmyra, N. Y.** The bulletin is designed to introduce pressure, temperature and other service requirements relative to the various kinds of metal packing available.

Write in No. 382 on Reader Service Card

TRANSISTORS—A new edition, the 4th, of the Transistor Manual has been published by **General Electric Co. Semiconductor Products Div., Dept. S/A, Charles Bldg., Liverpool, N. Y.** The new booklet contains 227 pages of completely re-written information on transistors and their use in electronic circuits.

Write in No. 383 on Reader Service Card

RELAY CONFERENCE — Complete papers of the Seventh Annual Conference on Electromagnetic Relays held at Oklahoma State University has been published by **American Machine & Foundry Co., Potter & Brumfield Div., Dept. S/A, Princeton, Ind.** 31 papers are included in the illustrated, 134 page booklet.

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more on page 294

32 years of experience . . . unequalled craftsmanship spell unchallenged leadership in the design and production of precision flight instruments, automatic celestial navigation, electromechanical, and avionic systems for the aviation industry.

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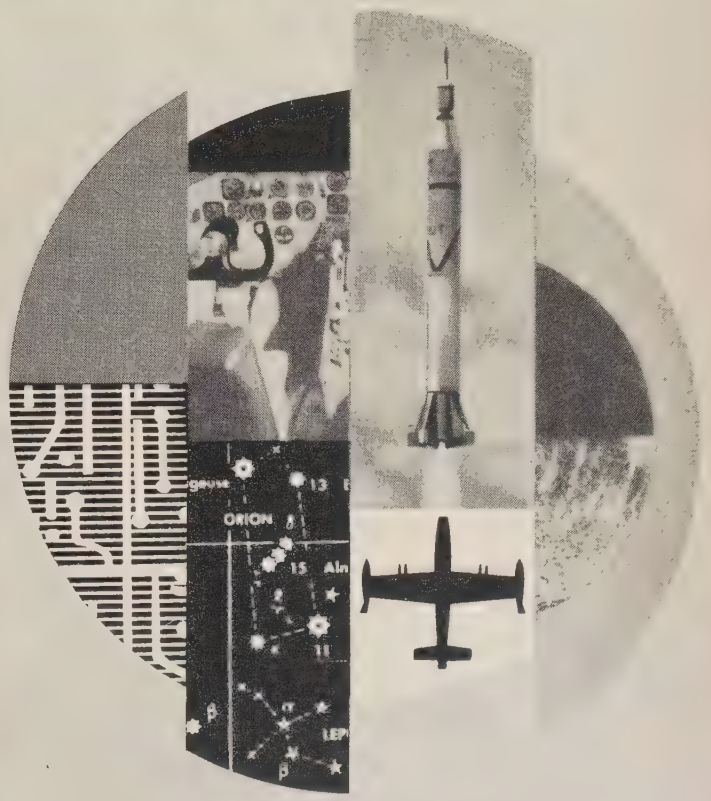

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Houston Fearless Astrodomes give sure environmental protection and fast directional mobility to cameras, telescopes and other instruments used in missile tracking. Airtight, weatherproof, they give effective insulation from solar heat—protect delicate instruments and personnel. Air conditioning available.

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TELEMETRY SYSTEM — Completely describing a telemetry system for drone battlefield surveillance, a bulletin containing a 3-page detailed block diagram and illustrations of the transmitting set is available from **Tele-Dynamics Inc., Dept. S/A, Parkside Ave., Philadelphia 31, Pa.** Display equipment provides "quick-look" indication and recording of operational conditions.

Write in No. 385 on Reader Service Card

SERVO VALVES—Operation and performance characteristics of its 71 series industrial servo valves are contained in bulletin 104 by **Moog Servocontrols, Inc., Dept. S/A, Proner Airport, East Aurora, N. Y.** It includes functional schematic, performance curves, and valve specifications as well as installation and overall dimensions.

Write in No. 386 on Reader Service Card

RESISTORS — An article describing precision matched resistor networks and their applications is available from **Pyrofilm Resistor Co., Dept. S/A, U. S. Highway 46, Parsippany, New Jersey.**

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TRANSISTOR MOUNTING KITS—A data sheet on transistor mounting kits is now available from **Bendix Aviation Corp., Red Bank Div., Dept. S/A, 201 Westwood Avenue, Long Branch, N. J.**

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SIGNAL SELECTOR—A data sheet on Model N663 Automatic Signal Selector for sine wave vibration testing is available from **MB Electronics Div., Textron Electronics, Inc., Dept. S/A, P. O. Box 1825, New Haven 8, Conn.**

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ROTARY TRANSDUCER — A rotary transducer, type RK3600 is described and illustrated in bulletin No. RK-AB by **Crescent Engineering & Research, Dept. SA, No. Peck Rd., El Monte, Calif.**

Write in No. 390 on Reader Service Card

SILICONE FLUIDS — Engineering properties of silicone fluids have been assembled in a design file, with charts, by **Union Carbide Corp., Silicones Div., Dept. S/A, 30 E. 42nd St., New York 17, N. Y.** Receivers will be registered to provide them with additional sheets and revisions. It is directed primarily to engineers engaged in designing shock absorbers, gyroscopes, hydraulic systems, suspension systems, damping devices, liquid springs, valve tappets, etc., where high temperatures and extreme conditions are a consideration.

Write in No. 391 on Reader Service Card

more on page 296

Materials Memo

News of materiel for the aerospace industry — from the 27,000 products of the 3M Company

■ **WRAP UP YOUR PRESERVATION PROBLEMS** — Ancient Egyptians had to get by with linen in preserving their birds (and people) — but there's no excuse for your using archaic materials for preservation sealing. Not when new "SCOTCH" BRAND Preservation Tape No. 481 can be had. This weather resistant plastic tape has been designed specifically to meet the preservation sealing requirements of the Armed Forces. Why, even after 2 year exposure to Texas weather, it showed no ill effects and what's more, could easily be removed. Need we say more about its ability to resist the elements?

Of course, if you've never been to Texas, you may want more particulars on the performance range of this pressure-sensitive adhesive backed construction. Application can be made over a temperature range from 25°F to 120°F. Once applied, it can be flexed even down to −60°F and performs well up to 160°F. You'll also find that #481 removes cleanly without adhesive transfer.

The unusually conformable backing of Preservation Tape means that it can be applied to irregular surfaces, even at low temperatures, and still provide an effective moisture vapor seal. Incidentally, it has an MVT of 0.4 grams per 100 square inches per 24 hours.

Other points well worth remembering. This tape's backing is inert to common fuels, lubricants, and oils. Nor do water-based or solvent-based strippable coatings have any adverse effects on it. If you're concerned about applying it over lacquered or enameled surfaces, have no fear. It won't stain even after weathering.

You may have your own ideas about applications for #481 tape. Others are already field testing it as a seam sealer on missile bodies, radar and instrumentation vans and miscellaneous ground support equipment. Your INDUSTRIAL TRADES TAPE representative can give you further data on this interesting product, or check the appropriate box below.

■ **TAKE IT COOL**

Does over-heating in your electronic components have you hot under the collar? Don't just go on frying your transistors, there's relief in sight. Recent developments in 3M's thermoelectric research now make it possible to literally pump away unwanted heat. In principle, these thermoelectric devices, based on the Peltier effect, can be tailored to fit a variety of hot spot cooling requirements whether they be in the tenths or tens of watts.

The number of couples built into a specific module depend upon the amount of heat to be moved and the temperature differential desired. For example, in a module containing four couples, one watt of heat will be pumped through a temperature differential of 75°F. Looking at it in another way, it will handle two watts at a differential of 50°F.

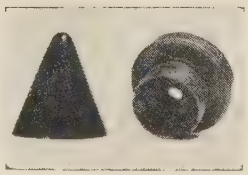
These thermoelectric spot coolers operate best with reasonably flat DC current. The maximum temperature differential across the elements in a given unit will occur at approximately 10 amps and an IR drop of 0.4 volts.

Developmental units designed by 3M are already at work cooling fluorescent tubes, transistors and electronic tubes. Our ELECTRICAL PRODUCTS DIVISION will be happy to consider the application of similar units to your systems or discuss with you the feasibility of custom building a suitable unit. You can start the ball rolling by checking with your local Electrical Products representative, or sending in the coupon below.

■ **A HOT TIP ON RE-ENTRY**

There's no need to sweat over finding materials for your individual nose cone or re-entry body construction. — Not when you can select from a series of new "SCOTCHPLY" ablative reinforced plastic materials. These are made up of various combinations of heat resistant resins and reinforcing fibers of glass, nylon, asbestos and other ablation materials.

All of these constructions are based on the exclusive "SCOTCHPLY" unidirectional fiber concept — which includes among its advantages an unequalled strength-to-weight ratio. Each individual ply is made up of a series of continuous non-woven filaments carefully impregnated with a closely controlled amount of the resin. This means several things to you in your layups. For one thing, you're relieved of the grief



and mess of maintaining uniform resin to reinforcement ratios. It's all done for you. Furthermore, you can tailor the reinforcing fiber orientation to suit your respective ablation needs or strength requirements.

You needn't worry that these materials haven't been put through the paces. They're real cool performers when the heat is really on. Tested in the G.E. water stabilized arc up to 20,000°F, some have exhibited rates down as low as 0.89 milligrams per kilowatt second. Thermal conductivity of several types is in the range of 1.5 BTU's per square foot per hour per degree Fahrenheit per inch. Those who aren't impressed by test data will be interested to know that members of this series have successfully survived re-entry on existing missile systems.

Our REINFORCED PLASTICS DIVISION proudly points out that while these are offered in 6 basic constructions, their equipment and experience is sufficiently versatile to permit constructions with other fibers and/or different resin concentrations (these, of course, on a minimum quantity basis). "SCOTCHPLY" ablative materials are available in uncured form, both as tapes and sheets. Why not get more data on their performance from your local Reinforced Plastics representative? Or check the box in the coupon below.

■ **ABOUT "MIL"**

3M's Missile Industry Liaison is a service staffed by technical personnel experienced in rocket propulsion and other phases of space technology. Their job is to translate problems of the aerospace industry to those 3M specialists best qualified to solve them. If you have questions on any of the items mentioned here, or would like to know what else 3M makes — or could make — for your needs, mail coupon.

3M Company, Missile Industry Liaison — Dept. VAA-30
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POTENTIOMETER — Design detail and performance characteristics o the Model 3B Vernistat precision a.c potentiometer are described in a 2 page data sheet now available from **Vernistat Div., Perkin-Elmer Corp. Dept. S/A, Norwalk, Conn.** Importan features covered in the bulletin are its low quadrature, high resolution and high input impedance.

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COUPLINGS—The "15 series" o quick connect-quick disconnect valved couplings are described in catalog No. 280B by **Snap-Tite, Inc. Dept. S/A, Union City, Pa.** Cutaway drawings, dimensional data, and selections of end threadings for six sizes of couplings are included. Accessory items are illustrated and detailed.

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SERVO MOTORS—An illustrated 170 page catalog of Synchros, Servo Motors, Servo Amplifiers, Resolver Rate Gyros and Potentiometers is available from **United Aircraft Corp Norden Div., Dept. S/A, Commack N. Y.** The catalog contains specifications and outline drawings of 200 units.

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COAXIAL CONNECTORS—A catalo of standard TNC connectors and their aluminum series coaxial connectors is available from **General RF Fittings Inc., Dept. S/A, 702 Beacon St., Boston 15, Mass.**

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VARIABLE TRANSFORMERS—Cased variable transformers, "overvoltage" and "no-overvoltage", are described in bulletin 151 by **Ohmite Mfg. Co., Dept. S/A, 3649 Howard St., Chicago, Ill.** Products are illustrated and technical data and prices are included.

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INERTIAL GUIDANCE — Two new bulletins, In-052 and In-026, on inertial guidance control test equipment have been published by **J. W. Fecker, Inc., Dept. S/A, 6592 Hamilton Ave., Pittsburgh, Pa.**

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COMPUTER ELEMENTS—A 24-page color brochure describing their digital computer elements is available from **Ford Motor Co., Aeronutronic Div., Dept. S/A, Ford Road, Newport Beach, Calif.** These elements are multi-aperture devices made from conventional ferrite materials and are in order of magnitude faster than former magnetic devices.

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more on page 298

He smashed the sound-in-water barrier

Because its energy passes only through air, radar can pick up targets hundreds of miles away. The ocean isn't so cooperative: water rapidly absorbs all types of energy. How do you breach this barrier to produce a really long-range underwater surveillance system?

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AMPLIFIERS—Five two-page bulletins No. 1592 and 1597 describing the complete line of miniature, lightweight amplifiers and power supplies for magnetic tape recordings are available from **Data Tape Div., Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** Photographs and drawings illustrate operation, specifications, and applications.

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RECORD READERS—Quick reference catalog discusses the various types of record readers produced by **Benson-Lehner Corp., Dept. S/A, 11930 West Olympic Blvd., Los Angeles 64, Calif.** The catalog discusses special purpose record readers which are used to convert information recorded in pictorial or graphic form into either digital or proportional analog resistance form.

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NAVIGATION SYSTEM — A 4-page bulletin on a Doppler navigation system for commercial aircraft is available from **General Precision Laboratories Inc., Avionic Commercial Sales, Dept. S/A, Pleasantville, N. Y.** Especially designed for commercial aviation the system is engineered with full attention to airline requirements specified in ARINC characteristics 540 and 543.

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CIRCUIT ACCESSORIES — Industrial molded case circuit breaker accessories and modifications are described in a bulletin by **General Electric Co., Circuit Protective Devices Div., Dept. S/A, 90 Whiting St., Plainville, Conn.** The publication, GEA-6757, provides information necessary to select, specify and order. Products are illustrated and supplemented by outline dimensional drawings.

Write in No. 402 on Reader Service Card

ANALOG COMPUTER—Bulletin No. AC934 describing their latest development in the field of analog computation—the Pace TR-10 transistorized, portable analog computer, is available from **Electronic Associates, Inc., Dept. S/A, Long Branch, N. J.** The brochure describes how the engineer can learn to operate the Pace TR-10 as easily as he learned to use a slide rule.

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DIELECTRIC MATERIAL—A colorful chart giving properties of Dielectric Materials at Microwave Frequencies over a wide range of dielectric constant and dissipation factor is available from **Emerson & Cuming, Inc., Dept. S/A, Canton, Mass.**

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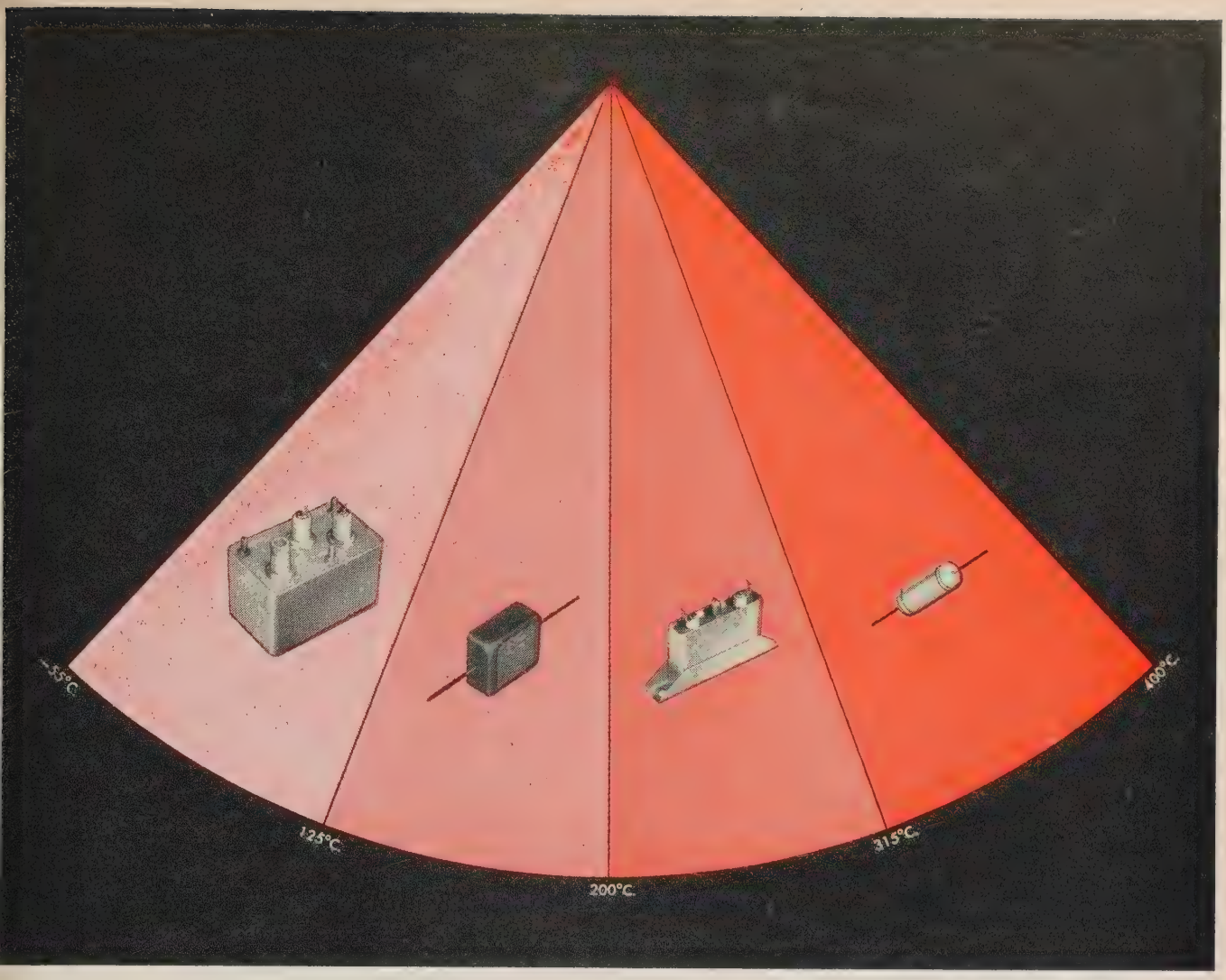

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No voltage derating **Solid impregnants** **Wound mica papers** **Exceptional stability**

Under 125°C.—Specials
• Size and weight reductions at high voltages • Drift—.25% capacitance change typical from −55°C. to +125°C. • High I. R.—1500 megohm X microfarads typical at 125°C. • Solid impregnants—no liquid leakage.

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• .001 to 6.0 mfd., 200 V to 3 KV, specials to 10 KV. • Molded and metal housed; tubular and rectangular • Size and weight reduction—over plastic film and stacked mica types, particularly at high voltages • Drift—1% capacitance change typical from −55°C. to +200°C. • High I. R.—50 megohm X microfarads typical at 200°C. • Proved in 4 years' usage.

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• .05 to 4.0 uf, 600 V and up • Drift—3% capacitance change typical from −55°C. to +315°C. • High I. R.—10 megohm X microfarads typical at 315°C. • Nothing smaller at 315°C.

315°C. to 400°C.—In development
• .001 to 6.0 uf, 150 V and 600 V • Drift—5% capacitance change typical from −55°C. to +426°C. • High I. R.—1 megohm X microfarad typical at 400°C. • Prototype availability • Only inorganic materials used.

For full details, write:

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McDONNELL VOODOO

Above 1200 mph, it isn't enough to put just mechanical "muscle" at the pilot's command; he needs an assist with "mental" aerobatics, too.

Teaming-up with McDonnell engineers, the specialists of the Aeronautical Division at Minneapolis-Honeywell Regulator Company turned out a mechanical co-pilot specifically for the F-101B. For nerves and sinews in this M-H Autopilot, they specified Hitemp Teflon* coated wire and cable.

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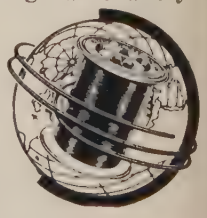
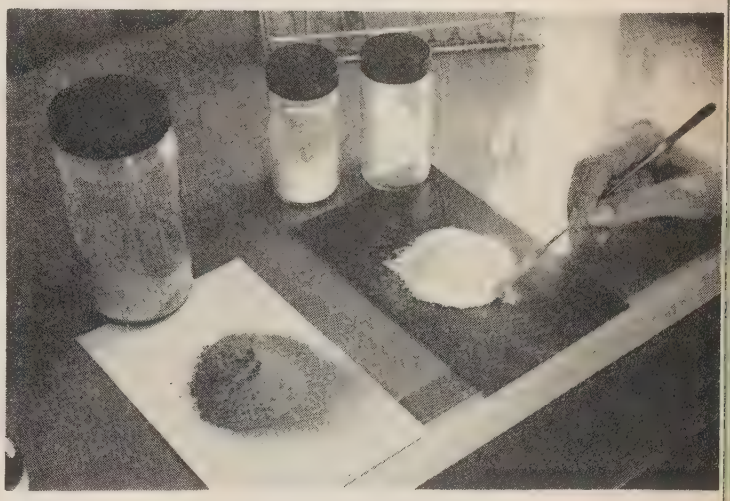


*Registered trademark for DuPont fluorocarbon resins.

Visit our Booth Number 4213, I.R.E. Show, N.Y.C.
Write in No. 252 on Reader Service Card at start of Product Preview Section

PASSENGER comfort is emphasized in the Soviet Union's new Yak-24 transport helicopter. The twin-rotor design seats eight in a soundproofed cabin with big windows. "Automatic control stabilization" is also claimed by the Russians.



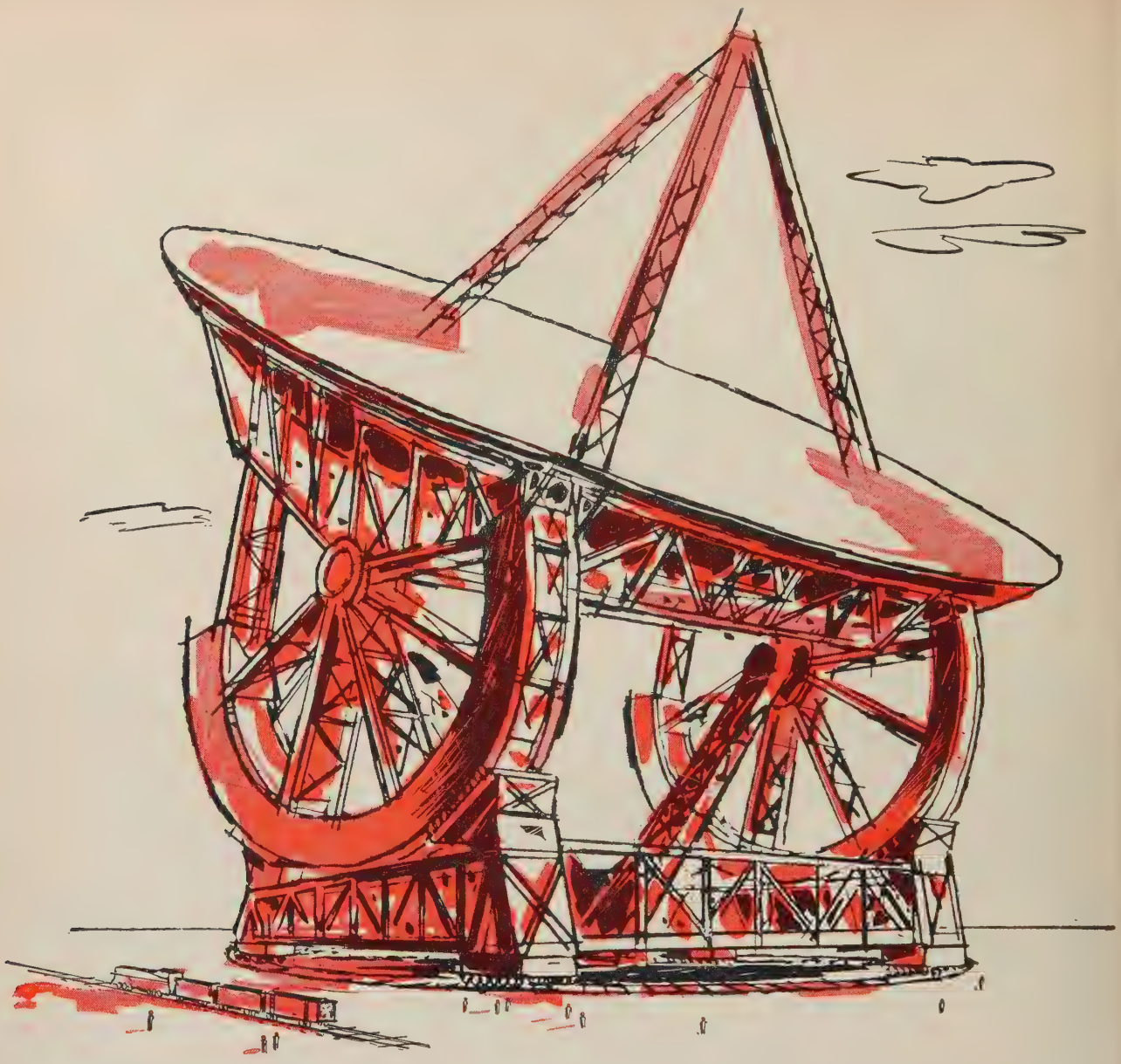
BLANCHED ALGAE (above right) have it all over the green product (above left), say Boeing scientists. Their better looks and taste should make them palatable to space crews. Left: "Balloonite" designed by Schjeldahl, of Northfield, Minn., is to be shot into orbit this spring. Thirty feet in diameter when inflated, it will be ejected from a canister only 11 in. in diameter.

Aerojet-General set up a Structural Materials Division at Azusa, Calif., to exploit more fully its work in materials and processes. The new group combines the company's Structural Plastic Division and the Materials Department of the Azusa operation.

Servo Corp. of America, Hicksville, N.Y., moved into the industrial-instrumentation field by acquiring Electro-Pulse, of Culver City, Calif., which makes pulse generators, electronic counters, and plug-in circuit modules.

Lockheed-Georgia created a new Aerospace Technology Department under R. B. Ormsby. The group will study hypersonic ramjet aircraft, boost-glide missiles, orbital vehicles, and re-entry devices.

more on page 303



Huge radio telescope for celestial exploration and space communication. Note how freight train is dwarfed by it.

Loewy plays vital role in design and construction of world's largest radio telescope

Loewy-Hydropress, well established in the design and construction of testing and launching installations for missiles and rockets, has extended its activities into the field of radio telescopes and allied equipment. Loewy is currently making a major contribution to the world's largest telescope (now under construction for the U.S. Navy) by designing and building the huge bearings, drives, supports and other mechanical elements which motivate altitude and azimuth position and control the fine balance of the structure.

In addition to the Navy project, Loewy engineers have been working on another enormous telescope, one with a reflector diameter of approximately 300 ft. And they have also been instrumental in the development of the complex mechanisms and structures for large radar tracking antennas.

For information that could be helpful in your structural and mechanical problems concerning radio telescopes and radar antennas for scientific and ordnance requirements, write Dept. R-3.

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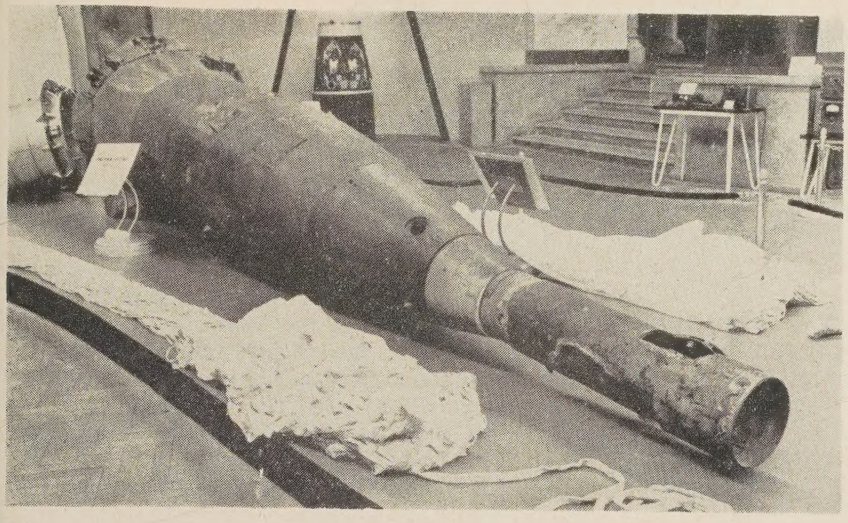
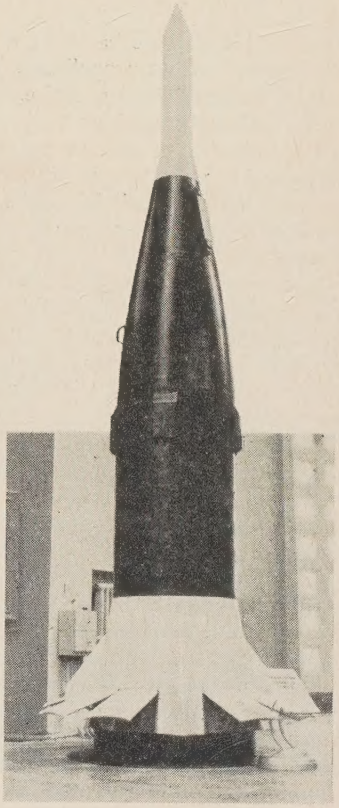
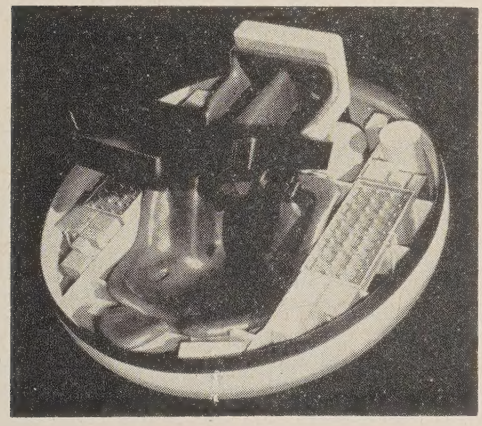


RECOVERED high altitude payload capsule and the front end of a high altitude rocket were displayed by Russians. The nose (below) probably was carried by a modified IRBM. It is bigger than that of any comparable U.S. high altitude vehicle. The recovery capsule (left) has what looks like a remarkably rugged forward bulkhead.





"SPACE COUCH" for the Mercury project was designed by American Latex Products. For each Astronaut, a couch will be custom-molded from foamed Stafoam urethane plastic.

Link Division, General Precision, set up a new R&D Lab in College Park, Md., to develop electromechanical and electronic equipment. The devices, designed for missile range instrumentation, missiles and space vehicles, ground support, and similar applications, will be manufactured at Link's Binghampton, N.Y., plants after development at College Park.

Director of the new Link Lab is Owen E. Cunningham, formerly technical director for Fairchild's Applied Science Division.

General Telephone & Electronics set up a wholly-owned subsidiary, General Telephone & Electronics Labs, with a New York City headquarters, to conduct research in the communications and electronics field. President is Dr. Herbert Trotter, senior vice-president for research and engineering for Sylvania, which is also a GT&E subsidiary.

Sylvania's Bayside, N.Y., research labs will be the nucleus of the new GT&E Labs. Other facilities will be added as work expands.

Ryan Aeronautical, San Diego, beefed up its electronic capabilities by acquiring control of Aerolab Development, of Pasadena, Calif., a firm specializing in aerophysics research. T. Claude Ryan, president, says Aerolab will help improve Ryan's automatic guidance work by its ability to produce multi-stage rocket propulsive units and by its operational experience in missile firing. Aerolab's telemetry and instrumentation capabilities will also complement Ryan's upcoming space work, he adds.

What makes a "super" propellant?

by David Lippman,
Research Analyst, The Fulton-Irgon Corp.*

RECENTLY there has been a flood of reports about new "super" rocket propellants. Very few of these propellants actually show promise. Some are plain duds—careful calculations show they won't perform even as well as propellants now in use. Others do have a high theoretical specific imulse (I_{sp}) but are so bad in other respects that they will be useful only in a few, highly specialized applications, if at all. Here are a few examples:

Lithium perchlorate got wide publicity as a superior solid oxidizer, mainly because of its large oxygen content—60 per cent by weight. Old-fashioned ammonium perchlorate, it so happens, contains just as much oxygen by weight. The point is, of course, that oxygen content alone isn't a good criterion for evaluating oxidizers.

The real test of an oxidizer is the I_{sp} that it will give with a fuel. With decaborane, one of the best boron-containing solid fuels, lithium perchlorate gives 265 seconds—but ammonium perchlorate gives 280. With acetylene, representative of the high energy organic fuels, lithium perchlorate gives 250 seconds, ammonium perchlorate gives 255.

In addition, lithium perchlorate is costly and in short supply compared with ammonium perchlorate or ammonium nitrate, and it is highly hygroscopic. Its one good characteristic is its high density—25 per cent higher than that of ammonium perchlorate. What it all comes down to is that there is no reason to believe lithium perchlorate will ever be used as a rocket oxidizer, except perhaps in a few cases in which high density is needed.

At first glance, *liquid hydrogen* really looks like the fuel of the future. The combination of hydrogen and fluorine gives an I_{sp} of 379 seconds, as against 271 seconds for jet fuel and oxygen.

Let's say you have a vehicle with an empty weight of 10 tons and a propellant load of 60 tons. If fired vertically at 200,000 lb thrust, it will reach a speed of 11,700 fps with jet fuel and oxygen propellant (neglecting air drag). Hydrogen and fluorine will give a speed of 16,400 fps under the same conditions.

Unfortunately, a second look shows that hydrogen is not such a good fuel. Most important is its very low density of 0.07 gm/cm³. The average density of the hydrogen-fluorine combination is only 0.32 gm/cm³, as against 0.98 gm/cm³ for the jet-fuel-oxygen combination. So the vehicle that held 60 tons of jet fuel and oxygen actually can hold only 20 tons of hydrogen and fluorine. With this propellant load, its top speed would be only 11,000 fps.

Suppose you redesign your vehicle to hold 60 tons of hydrogen-fluorine propellant. The tanks now will have a volume 0.98/0.32, or roughly three, times that of the original tanks, and their weight will be about $3^{2/3}$, or 2.1, times that of the original tanks. (The surface area, and therefore the weight, of a tank increases as the two-thirds power of the volume.)

Assume that, in the original vehicle, the weight of the tanks and associated equipment determined by propellant volume is six tons. Then the tank weight of the new vehicle will be 12.5 tons, giving a total empty weight 16.5 tons. The top speed of this vehicle will be 11,400 fps—less than the speed of the original vehicle using jet fuel and oxygen.

The average density of the hydrogen-fluorine combination can be raised by increasing the ratio of fluorine to hydrogen, but this decreases I_{sp}. A hydrogen-fluorine combination with an average density of 0.75 gm/cm³ gives 338 seconds I_{sp}. If it is substituted for jet fuel and oxygen in our vehicle, speed will go up from 11,700 to 13,700 fps.

High price is paid for increase

This is a big increase, but a high price must be paid for it. Both hydrogen and fluorine are cryogenic materials. Hydrogen, having a far lower boiling point than oxygen, is much harder to store and use. Fluorine is poisonous, very corrosive, and explodes on contact with many materials. The exhaust gases from hydrogen-fluorine are toxic and corrosive. Shifting from jet fuel-oxygen to hydrogen-fluorine increases the flame temperature in the combustion chamber from 5880 to 8530 deg F, making worse an already tough cooling problem. Because more low temperature insulation, corrosion- and heat-resistant materials, and elaborate combustion chamber cooling are needed, a hydrogen-fluorine rocket will be heavier than one using jet fuel-oxygen. The added weight will reduce the speed advantage.

We can conclude that hydrogen and fluorine can be useful only in very large vehicles (whose tanks account for only a small portion of overall weight) and only when high speed is so important that safety, reliability, convenience, and economy can be ignored.

High I_{sp} isn't enough. Stability, density, cost, availability, burning rate, toxicity, flame temperature, compatability with materials of construction, and mechanical properties must also be considered. A true super propellant is not necessarily—or even usually—one that gives very high I_{sp}. It is a propellant that does a job with the greatest possible economy, safety, and reliability.—End

* The Fulton-Irgon Corp., P.O. Box 591, Dover, N.J.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

TACTICAL COMMUNICATIONS:

*

CRIMEA 1854

*

. . .'Forward the Light Brigade!
Charge for the guns!' he said.
Into the valley of Death
Rode the six hundred.

. . . Was there a man dismay'd?
Not tho' the soldier knew
Someone had blunder'd.
Theirs not to make reply,
Theirs not to reason why,
Theirs but to do or die.
Into the valley of Death
Rode the six hundred.

. . . Cannon to right of them,
Cannon to left of them,
Cannon behind them
Volley'd and thunder'd;
Storm'd at with shot and shell,
While horse and hero fell,
They that had fought so well
Came thro' the jaws of Death . . .
. . . All that was left of them,
Left of six hundred.

ALFRED LORD TENNYSON

RICHARD CATON WOODVILLE, JR. "Charge of the Light Brigade." Parker Gallery, London

Blundering tactical command in this age of quick-reaction military operations may not be similarly immortalized. Today, instantaneous and completely reliable Electronic Communications, both voice and tactical data link, provide the continuous two-way intelligence that precludes the blunders which sealed the fate of the Light Brigade.

ECI is proud to play an important part in insuring that such Electronic Communications exist for our defense in space, airborne and surface roles, with the creation of systems such as its fully integrated Model 28, 1 KW UHF Communication equipment, capable of inclusion in advanced Tactical Data Systems, as well as in airborne applications and in the nation's continually expanding systems of Early Warning.

One of a series of advertisements depicting historic incidents in military communications through the ages

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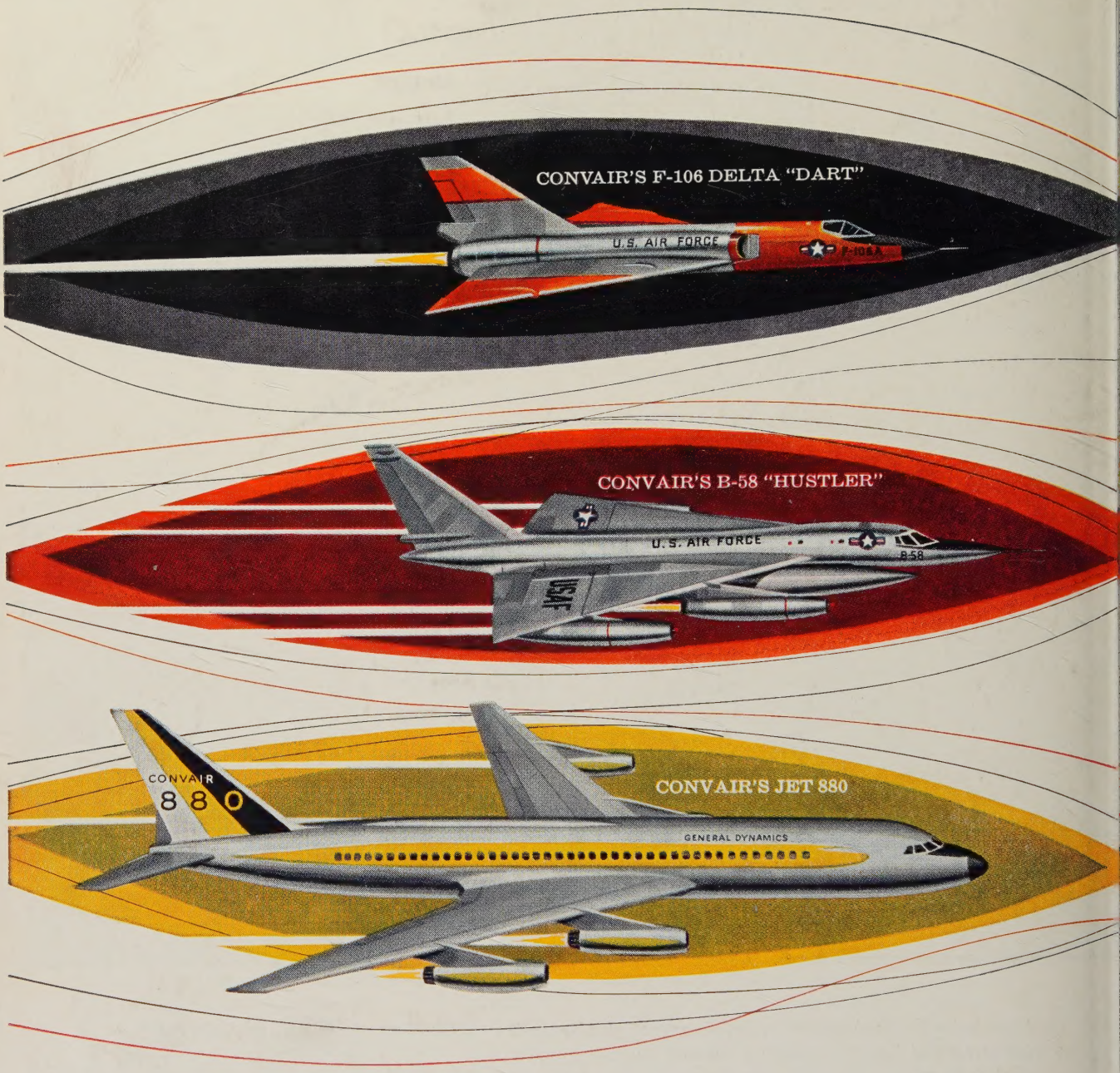

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